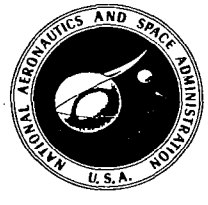
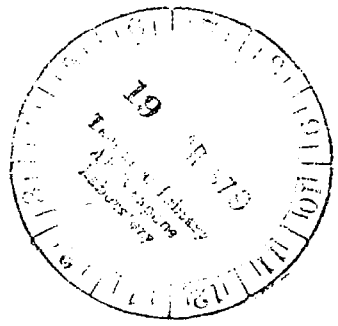
NASA Reference Publication 1032

Synoptic Analyses, 5-, 2-, 1-, and 0.4-Millibar Surfaces for July 1976 Through June 1977

DECEMBER 1978





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Synoptic Analyses, 5-, 2-, 1-, and 0.4-Millibar Surfaces for July 1976 Through June 1977

Prepared by Staff, Upper Air Branch
National Weather Service
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CONTENTS

ILLUSTRATION

SYNOPTIC ANALYSES, 5-, 2-, 1-, AND 0.4-MILLIBAR SURFACES, FOR JULY 1976 THROUGH JUNE 1977

by Staff,[1] Upper Air Branch
NOAA, National Weather Service, National Meteorological Center

SUMMARY

Meteorological rocketsonde and satellite radiance data are employed for analyses of a continuing series of high-altitude constant-pressure charts. The automated methods of data processing and the objective analysis procedures are described.

Broad-scale analyses of temperature and geopotential height for the Northern Hemisphere 5-, 2-, 1-, and 0.4-mb surfaces are presented for each week of the period July 1976 through June 1977. Brief discussions of the variations of the temperature and height fields throughout the period are also given.

INTRODUCTION

This report is the ninth in a series of constant-pressure charts for the upper stratosphere and lower mesosphere. Previously, 5-, 2-, and 0.4-mb charts for 1964-68 (refs. 1, 2, 3, 4, and 5) were analyzed at weekly intervals and were based primarily on meteorological rocketsonde data obtained throughout North America and adjacent ocean areas (refs. 6 and 7). Beginning with charts for 1972 the analyses were extended to most of the Northern Hemisphere (refs. 8, 9, and 10). Figure 1 shows the

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[1]Personnel actively engaged in this project are: Manager, F. G. Finger; Coordinator and Analyst, M. E. Gelman; Analyst, L. J. Hortch; Systems Developers, R. M. Nagatani and J. D. Laver; Research Consultants, R. S. Quiroz and A. J. Miller; and data processing, D. L. Griffith, J. D. Kopman, and J. A. Peters.

locations of the 20 meteorological rocket launch sites for which data are available. Data from satellite vertical temperature sounding instruments have been used since 1972 (see section on satellite data, below). The use of satellite information, together with rocket observations, provides greatly improved data coverage over the entire hemisphere.

This series, from July 1976 through June 1977, contains charts for the 1-mb level, which have been constructed in addition to those analyses for the other levels. In addition, the newly developed objective (automated) method of analysis employed (ref. 11) (discussed in the Analysis Procedure Section, below) is different from the manual analysis methods used in previous years.

These weekly (Wednesday) analyses of the 5-, 2-, 1-, and 0.4-mb surfaces (approximately 36, 42, 48, and 55 km, respectively) portray the broad-scale synoptic conditions over the Northern Hemisphere. Relatively small-scale time and space changes (refs. 12 and 13) are known to occur during summer, but the horizontal resolution of the analyses in most areas is still not sufficient to depict them. During winter and the transition periods, large-scale changes are usually evident from one week to the next. Sometimes, these variations occur within a day or two and may be inferred from the sequence of up to three observations plotted at some rocket stations. The user may greatly enhance the utility of the weekly charts by noting any large changes during the week in plotted temperature or wind direction, thus inferring movement of the synoptic systems.

Despite the omission of the smaller-scale details, the maps are useful for a number of applications. Examples include: determining the trajectory of constant-level balloons; relating variations in infrasound propagation to circulation changes; and providing a data base (climatological and synoptic) for evaluating environmental effects of aerospace vehicles. In addition, users have pointed to the increasing utility of these maps for studying transport and diffusion of atmospheric constituents, for studies of stratospheric-ionospheric interaction, for validation of numerical prediction models, and for various other research efforts.

PROCESSING OF ROCKETSONDE DATA

Temperature, height, and wind information derived from routine meteorological rocketsonde observations comprise the basic data for analyses at the 5-, 2-, 1-, and 0.4-mb levels.

A computerized system has been used for collecting, decoding, and processing teletype coded ROCOB messages (WMO code RM39.E ROCOB and FM40.E ROCOB ship). These data are transmitted from each rocketsonde station, usually within one day of observation. Data from Heiss Island, Volgograd, mobile U.S.S.R. ships, and Thumba are available in ROCOB format within one week of observation time.

International (WMO-sponsored) rocketsonde intercomparisons (ref. 14) have shown large differences between temperatures reported from U.S. and U.S.S.R. soundings, even after each set of data has been "corrected" according to theoretical and laboratory results (ref. 15). For this reason further adjustments to temperatures reported in ROCOB messages are applied to U.S.S.R. data. Reported U.S.S.R. ROCOB temperatures are raised by amounts of 2°C at 50 km, 7°C at 55 km, and 9°C at 58 km, as recommended in ref. 14.

The computerized procedure for calculating pressure and extracting the required information for the 5-, 2-, 1-, and 0.4-mb levels (patterned after the procedure in ref. 16) is as follows:

a. Pressure is calculated at each ROCOB reported level by integrating the hydrostatic equation starting at a base level of 50, 30, or 10 mb. Base level temperature and height data are obtained at the locations of the rocket stations from daily 1200 GMT charts produced by the National Meteorological Center (ref. 17). From the resulting pressure-temperature-height profile, the geopotential heights and temperatures at the 5-, 2-, 1-, and 0.4-mb levels are interpolated.

b. Wind direction and wind speed are interpolated using the computer procedure in ref. 16 at the calculated height of each analysis level. When temperature data are not available for a particular sounding, the wind information is extracted manually at individually estimated heights of the 5-, 2-, 1-, and 0.4-mb levels.

c. Time-height diagrams are plotted by computer for each rocketsonde station. The temperature and wind information on these diagrams provides verification of the sequence of meteorological changes during each month. In addition, erroneous or questionable data are quickly isolated.

d. From the wind information on the time-height diagrams, thermal winds are determined for approximately 6-km layers centered on each analysis level. Although at times there are rapid wind oscillations with height, an unambiguous direction for the thermal wind can usually be determined.

PLOTTING OF DATA

The rocketsonde data--temperature (°C), height (geopotential meters), and wind direction and speed (knots)--are plotted on a polar stereographic map base. On the charts presented for publication, three available observations closest to Wednesday are shown for each station whenever possible. Reported heights and calculated thermal winds have been omitted for the sake of legibility. The station model chart (Fig. 1) illustrates the symbols used to distinguish Wednesday data from those obtained on other days of the week.

USE OF SATELLITE DATA

Data from the NOAA 4 and 5 Vertical Temperature Profile Radiometer (VTPR) (ref. 18) were also used in deriving the 1976-77 height and temperature fields.

The method of using the remotely sensed temperature information for determining stratospheric thickness is given in ref. 19. In brief, the radiant energy sensed by a satellite instrument in any spectral band is representative of the weighted temperature from a substantial layer in the atmosphere. VTPR channel 1 (668 cm^{-1}) has a weighting function peaking near 30 mb, and about 80 percent of the energy it contains comes from the 100- to 2-mb layer. Channel 2 (678 cm^{-1}) weighting function peaks near 70 mb, with about 80 percent of the energy it senses obtained from the 100- to 5-mb layer. Regression equations were derived relating satellite-measured radiances and coincident radiosonde-rocketsonde computed thicknesses (or mean temperatures) of the layers between 100 and 5 mb, 100 and 2 mb, 70 and 1 mb, and 10 and 0.4 mb; also relating radiances and rocketsonde temperatures.

The relationships for NOAA 4 used from July through September 1976 are listed in ref. 10. The dependent sample from which the NOAA 5 regression relationships were derived was updated three times during the course of analyzing the October 1976 through June 1977 charts. Table 1 shows the relationships for a sample of 310 soundings collected from August 1976 through July 1977.

The relationships between satellite-measured radiances and radiosonde-rocketsonde temperature and thicknesses derived from the dependent set were used as an aid in constructing these analyses in the following manner:

a. Radiances measured from NOAA VTPR stratospheric channels 1 and 2 collected over a 24-hour period were analyzed objectively on the NMC 65 x 65 Northern Hemisphere polar stereographic grid.

b. Radiance values for channel 1 (I1) and channel 2 (I2) at each of the 65 x 65 grid points were then converted to thickness and temperature values using the regression relationships (e.g. Table 1).

c. Heights at the 5-, 2-, 1-, and 0.4-mb levels were obtained by adding to the thickness obtained in b above at each grid point, the height of the appropriate base level. The base level for 5 and 2 mb calculation was provided by the NMC 100-mb chart (ref. 17). For 1 and 0.4 mb, the base levels were 70-mb and 10-mb charts, respectively.

TABLE 1

	Regression Relationships*	R	SE
Thickness			
100-5 mb	$10179 + 290.2(I2) - 1.940(I2)^2$	.963	183 m
100-2 mb	$15591 + 242.8(I1) - 1.000(I1)^2$	.972	248 m
70-1 mb	$12827 + 419.1(I1) - 2.267(I1)^2$	.975	299 m
10-0.4 mb	$15886 + 270.5(I1) - 160.7(I2)$	.973	297 m
Temperature			
at 5 mb	$-158.7 + 2.786(I1) - 0.01518(I2)^2$	.948	4.7 C
at 2 mb	$-119.3 + 3.909(I1) - 2.551(I2)$	.958	5.2 C
at 1 mb	$-38.4 + 8.691(I1) - 10.762(I2) + 0.09276(I2)^2 - 0.05117(I1)^2$	.907	6.7 C
at 0.4 mb	$-34.4 + 0.01087(I1)^2 - 0.00682(I2)^2$	.551	8.8 C

R, correlation coefficient; SE, standard error of estimate.

*Regression relationships derived from 310 coincident rocketsonde/radiosonde-VTPR soundings.

A weaker statistical relationship exists between radiance and the temperature at any particular level than exists between radiance and the mean layer temperature or thickness. However, it was found (ref. 20) that regression relationships involving VTPR channels 1 and 2 specified the temperature at 5, 2, and 1 mb to a good approximation. Although very little real infor-

mation about the variability in 0.4-mb temperature is obtained from the VTPR regressions (as seen in Table 1), they provide a useful background field for the automated analysis. Thus, first guess 5-, 2-, 1-, and 0.4-mb temperature and height fields of July 1976 to June 1977 were derived by computer methods using the VTPR regression relationships.

An adjustment was made to the first guess height fields derived from the VTPR data beginning January 1977. At each (65 x 65) grid point a check was made of the level-to-level hydrostatic consistency of the height and temperature first guess fields. If the thickness as defined by the height fields at successive levels was different by more than 100 gpm from the thickness as computed from the mean temperature defined by the temperature fields at the successive levels, then the height at each level was changed to reduce the difference to 100 gpm. This procedure was found to improve the agreement of the first guess fields with rocket data and also to provide more hydrostatically consistent first guess fields, especially in tropical latitudes.

ANALYSIS PROCEDURE

A new analysis procedure was instituted with the charts beginning July 1976. Previously, the height and temperature fields at the 5-, 2-, and 0.4-mb levels, based on rocket and satellite information, had been subjectively analyzed. A new computer analysis system was developed (ref. 11), based on adaptations from other objective analysis techniques at tropospheric (refs. 21, 22) and lower stratospheric levels (ref. 23). The method depends on successive adjustment of a first guess field (on a 65 x 65 grid) to conform with temperature, height, and wind data derived from rocketsonde observations. This upper stratospheric, lower mesospheric objective analysis system is specially designed to make use of rocket data as the primary source of data for analysis, with satellite-sounder information as first guess information.

The first guess charts are adjusted for rocket observations closest to Wednesday using a maximum scan radius of 9 grid intervals (381 km per grid interval) for temperature and for height, going through six iterative scans, each iteration involving one grid interval less than the previous one. Winds from the rocket observations are also used in adjusting the heights (ref. 22). Smoothing operations are performed on the fields after the scans for data are completed and a vorticity amplifier used after the final scan to restore the amplitude of the large-scale systems. The overall procedure is found to

provide smooth and meteorologically consistent fields by spreading the influence of the sparse rocket data over a reasonable distance surrounding the station location.

The "rocket analysis" is the name given to the fields produced after completing the objective analysis scans using rocket data to adjust the first guess fields. Only seldom do the rocket data alone allow completely satisfactory depiction of the circulation and temperature features at the 5-, 2-, 1-, and 0.4-mb levels. Usually the meteorologist monitoring the analyses is not completely satisfied with the results of the totally objective rocket analysis. Some of the reasons for seeking to improve the rocket analysis lie in two problem areas: data errors, and problems due to sparse data.

In order to overcome these deficiencies, a system involving a man-machine mix has been incorporated into the analysis procedure. After the rocket analysis has been produced, the monitoring meteorologist may reject, change, or add temperature, height or wind data. Bogus data are added to aid in the depiction of features which are known to exist on the basis of earlier data but which are ill-defined by current data. For example, time continuity from one week to the next may suggest, even in the absence of rocket data for that week, that a ridge or a trough should be maintained to preserve consistency with respect to time. Vertical consistency is also a factor, especially if the rocket data are not available at every analysis level. Thermal wind information provides important additional information on the location and extent of temperature features with respect to the rocket stations.

The "bogus analyses" at the 4 levels for each Wednesday are then derived, using the first guess fields used previously, but analyzing for the bogus data as well as the original data (with any necessary revisions). Hydrostatic consistency checks are displayed at each grid point, comparing the thickness fields between the various levels with the corresponding temperature fields. Any significant inconsistencies (greater than approximately 320 gpm) are investigated, and if necessary, additional revisions or bogus data are introduced. Final charts are usually produced after one to three bogus runs.

The maps presented here were traced by hand from computer printouts of the final charts. A contour interval of 320 gpm for height and 5°C isotherm interval for temperature have been maintained. Centers of high and low height at the constant pressure levels are labeled using H and L symbols, respectively.

THE STRATOSPHERIC CIRCULATION FROM JULY 1976 TO JUNE 1977

A stratospheric-tropospheric warming in mid-winter of 1976-77 makes this year's series of high-level analyses particularly interesting. The periods shown by the maps for November 24, December 15 through January 19, and February 23 through April 13 involve episodes of dynamically disturbed conditions, when the polar vortex was affected in a variety of ways. These disturbed conditions reflect variable thermal activity within the stratosphere and they may also be modulated by the strength and placement of the long planetary waves in the troposphere.

In contrast, periods centered on about November 3, December 8, and February 9 are periods when strong poleward gradient of mean stratospheric temperature prevailed, reflecting a relatively undisturbed state of the stratosphere. These periods are also associated with a well-developed polar-night cyclonic vortex, as can be seen by reference to the accompanying 2-mb maps for those dates.

Visually, the maps present a kaleidoscopic set of patterns which may appear confusing. Part of the difficulty might be due to the weekly time separation of the maps; charts at weekly intervals are not sufficient to depict some events adequately. As a guide for our discussion, the circulation patterns from July 1976 to June 1977 can be grouped as follows:

a. July to mid-August. Warm summer pole and well-developed polar anticyclone, with strongest easterly winds in July and at highest levels.

b. Mid-August to mid-September. Breakdown of polar anticyclone, with weak temperature and height gradients; and in mid- to high latitudes, weak amorphous circulation systems. Polar anticyclone disintegrates first at 5 mb in this map series.

c. Mid-September to mid-October. Meridional temperature gradient reversed. Cold polar vortex dominates the circulation at all levels, but is best developed at highest level (0.4 mb).

d. Mid-October to mid-November. Dominated by radiational cooling, with strong stable polar vortex.

e. Mid-November to early December. Winter storm period begins, resulting in strongly disturbed condition. Partial reversal of poleward thermal gradient.

f. Early to mid-December. Return of strong stable polar vortex.

g. Mid-December to late January. Very strongly disturbed conditions, with substantial temperature gradient reversal about December 21 and full reversal in early January. Major warming event and circulation reversal (see discussion below).

h. Late January to February 20. Return of strong polar vortex, especially at the highest levels.

i. February 20 to mid-April. Strongly disturbed conditions, with full temperature gradient reversals after March 5, though temperature gradients remain weak. While the polar vortex seeks to re-establish itself during this period, as around March 2 and 23, it is much weaker than during mid-winter. Springtime circulation reversal achieved by early April.

j. Mid-April to mid-May. Weak anticyclone dominates polar circulation, but weak thermal and height gradients prevail.

k. Mid-May and June. Well-developed summer easterly circulation.

Separate discussion would be required of the flow patterns near the equator, which are dominated by a semiannual variation near 50 km and by a quasi-biennial cycle near 30 km. The westerly or weak easterly winds in January 1977 at 5 mb, for example, contrast significantly with strong easterlies in January 1976 (ref. 10); this contrast can be shown to be associated with the "quasi-biennial" oscillation of the tropical stratosphere.

The major event of December-January 1976-77. The important event of mid-winter 1976-77 has been described in detail (ref. 24, 25, and 26). In many ways, this event is similar to other major warmings of the past decade, insofar as it involved more than one thermal episode in high latitudes, accompanied by low-latitude cooling. Within the stratosphere, planetary wave 1 in the thermal and height fields achieved greater amplitude than wave 2 (ref. 24 and 27).

Two features tend to distinguish this particular event from all others namely: (1) the occurrence of unmistakably strong warming in the polar troposphere in January, after intense warming of the stratosphere, and (2) full reversal of the zonal circulation during mid-January at all heights from the surface to above the 10 mb level. Actually, this process occurred after a partial reversal (at 10 mb and above) in early January, which is not fully portrayed by the weekly maps (see maps for January 5). With the warming of the troposphere, the conditions were just right for the existence of an anticyclone during January 10-20 at all heights from the surface to the lower stratosphere, thence sloping toward Eurasia to 2 mb (see maps for January 12).

Cooling in the polar upper stratosphere after January 5 accounts for the evident slope and degradation of this anticyclone, as seen in the maps for January 12 and 19. Note the temperature reports at Thule, Greenland at 2 mb, which range from -55°C on December 28 (map for December 29) to +33°C on January 4 (map for January 5) to -40°C on January 17 (map for January 19). Synoptically, polar warming in the stratosphere can be traced by the poleward advance of a large-scale system of warm air from lower latitudes.

ACKNOWLEDGMENTS

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REFERENCES

1. Staff, Upper Air Branch, National Meteorological Center, "Weekly Synoptic Analyses, 5-, 2-, and 0.4-Mb. Surfaces for 1964," ESSA Technical Report WB 2, Weather Bureau, Environmental Science Services Administration, U.S. Department of Commerce, Silver Spring, Maryland, April 1967, 197 pp.

2. Staff, Upper Air Branch, National Meteorological Center, "Weekly Synoptic Analyses, 5-, 2-, and 0.4-Mb. Surfaces for 1965," ESSA Technical Report WB 3, Weather Bureau, Environmental Science Services Administration, U.S. Department of Commerce, Silver Spring, Maryland, August 1967, 173 pp.

3. Staff, Upper Air Branch, National Meteorological Center, "Weekly Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for 1966," ESSA Technical Report WB 9, Weather Bureau, Environmental Science Services Administration, U.S. Department of Commerce, Silver Spring, Maryland, January 1969, 169 pp.

4. Staff, Upper Air Branch, National Meteorological Center, "Weekly Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for 1967," ESSA Technical Report WB 12, Weather Bureau, Environmental Science Services Administration, U.S. Department of Commerce, Silver Spring, Maryland, January 1970, 160 pp.

5. Staff, Upper Air Branch, National Meteorological Center, "Weekly Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for 1968," NOAA Technical Report NWS 14, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland, May 1971, 169 pp.

6. Finger, Frederick G., Woolf, Harold M., and Anderson, Calvin E., "Synoptic Analyses of the 5-, 2-, and 0.4-Millibar Surfaces for the IQSY Period," Monthly Weather Review, Vol. 94, No. 11, November 1966, pp. 651-661.

7. World Data Center A, Meteorology, Data Report, Meteorological Rocket Network Firings 1964-1968, Vol. I-V, National Weather Records Center, Environmental Science Services Administration, U.S. Department of Commerce, Asheville, North Carolina, 1967-1971.

8. Staff, Upper Air Branch, National Meteorological Center, "Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for January 1972 Through June 1973," Joint NASA-NOAA Publication, NASA SP-3091, National Aeronautics and Space Administration, Washington, D.C., 1975, 205 pp.

9. Staff, Upper Air Branch, National Meteorological Center, "Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for July 1973 Through June 1974," Joint NASA-NOAA Publication, NASA, SP-3102, National Aeronautics and Space Administration, Washington, D.C., 1976, 140 pp.

10. Staff, Upper Air Branch, National Meteorological Center, "Synoptic Analyses, 5-, 2-, and 0.4-Millibar Surfaces for July 1974 Through June 1976," Joint NASA-NOAA Publication, NASA, RP-1023, National Aeronautics and Space Administration, Washington, D.C., 1978, 326 pp.

11. Gelman, M. E. and Nagatani, R. M., "Objective Analyses of Height and Temperature at the 5-, 2-, and 0.4-Mb. Levels Using Meteorological Rocketsonde and Satellite Radiation Data," Space Research, Vol. XVII, Pergamon Press, Oxford and New York, 1977, pp. 117-122.

12. Muench, H. Stuart, "Large-Scale Disturbances in the Summertime Stratosphere," Journal of the Atmospheric Sciences, Vol. 25, No. 6, November 1968, pp. 1108-1115.

13. Hirota, Isamu, "Spectral Analysis of Planetary Waves in the Summer Stratosphere and Mesosphere," Journal of the Meteorological Society of Japan, Vol. 53, No. 1, February 1975, pp. 33-44.

14. Finger, Frederick G., Gelman, Melvyn E., Schmidlin, Francis J., Leviton, Robert, and Kennedy, Bruce W., "Compatibility of Meteorological Rocketsonde Data as Indicated by International Comparison Tests," Journal of Atmospheric Sciences, Vol. 32, No. 9, September 1975, pp. 1705-1714.

15. Krumins, M. W., and Lyons, W. C., "Corrections for the Upper Atmosphere Temperatures Using a Thin Film Loop Mount," Technical Report 72-152, Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland, June 1972, 38 pp.

16. U.S. National Aeronautics and Space Administration, U.S. Department of Commerce, and U.S. Department of Defense, "Meteorological Rocket Observations," Federal Handbook No. 10, July 1975, approximately 250 pp.

17. NOAA, National Oceanic and Atmospheric Administration, "Constant Pressure Charts 850-10 Mb," National Climatic Center MF-494-76, 77, U.S. Department of Commerce, Asheville, North Carolina, 1976-1977.

18. McMillin, L. M., Wark, D. Q., Siomkajlo, J. M., Abel, P. G., Werbowetzki, A., Lauritson, L. A., Pritchard, J. A., Crosby, D. S., Woolf, H. M., Luebbe, R. C., Weinreb, M. P.,

Fleming, H. E., Bittner, F. E., and Hayden, C. M., "Satellite Infrared Soundings From NOAA Spacecraft," NOAA Technical Report NESS 65, National Environmental Satellite Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C., September 1973, 122 pp.

19. Quiroz, Roderick S., and Gelman, Melvyn E., "Direct Determination of the Thickness of Stratospheric Layers From Single-Channel Satellite Radiance Measurements," Monthly Weather Review, Vol. 100, No. 11, November 1972, pp. 788-795.

20. Quiroz, Roderick S., "The Stratospheric Evolution of Sudden Warmings in 1969-74 Determined From Measured Infrared Radiation Fields," Journal of the Atmospheric Sciences, Vol. 32, No. 1, January 1975, pp. 211-224.

21. Cressman, George P., "An Operational Objective Analysis System," Monthly Weather Review, Vol. 87, No. 10, October 1959, pp. 367-374.

22. Yanai, M., "An Experimental Objective Analysis In the Tropics," Technical Paper No. 62, Department of Atmospheric Science, Colorado State University, 1964, 22 pp.

23. Finger, Frederick G., Woold, Harold M., and Anderson, Calvin E., "A Method For Objective Analysis of Stratospheric Constant-Pressure Charts," Monthly Weather Review, Vol. 93, No. 10, October 1965, pp. 619-638.

24. Quiroz, Roderick S., "The Tropospheric-Stratospheric Polar Vortex Breakdown of January 1977," Geophysical Research Letters, Vol. 4, No. 4, April 1977, pp. 151-154.

25. Taylor, B. F., and Perry, J.D., "The Major Stratospheric Warming of 1976-77," Nature, Vol. 267, No. 5610, June 2, 1977, pp. 417-418.

26. Taylor, B. F., and O'Neill, A., "A Study of the Major Stratospheric Warming of 1976-1977," Quarterly Journal of the Royal Meteorological Society, submitted for publication, 1978.

27. Quiroz, Roderick S., "Contrasting Planetary Wave And Zonal Mean Behavior In Two Consecutive Winters (1975-76 And 1976-77)," paper submitted at IAGA/IAMAP Joint Assembly, 22 August-3 September 1977, Seattle Washington, Collection of Extended Summaries, available from NCAR, Boulder, Colorado, pp. 11.1-11.5.

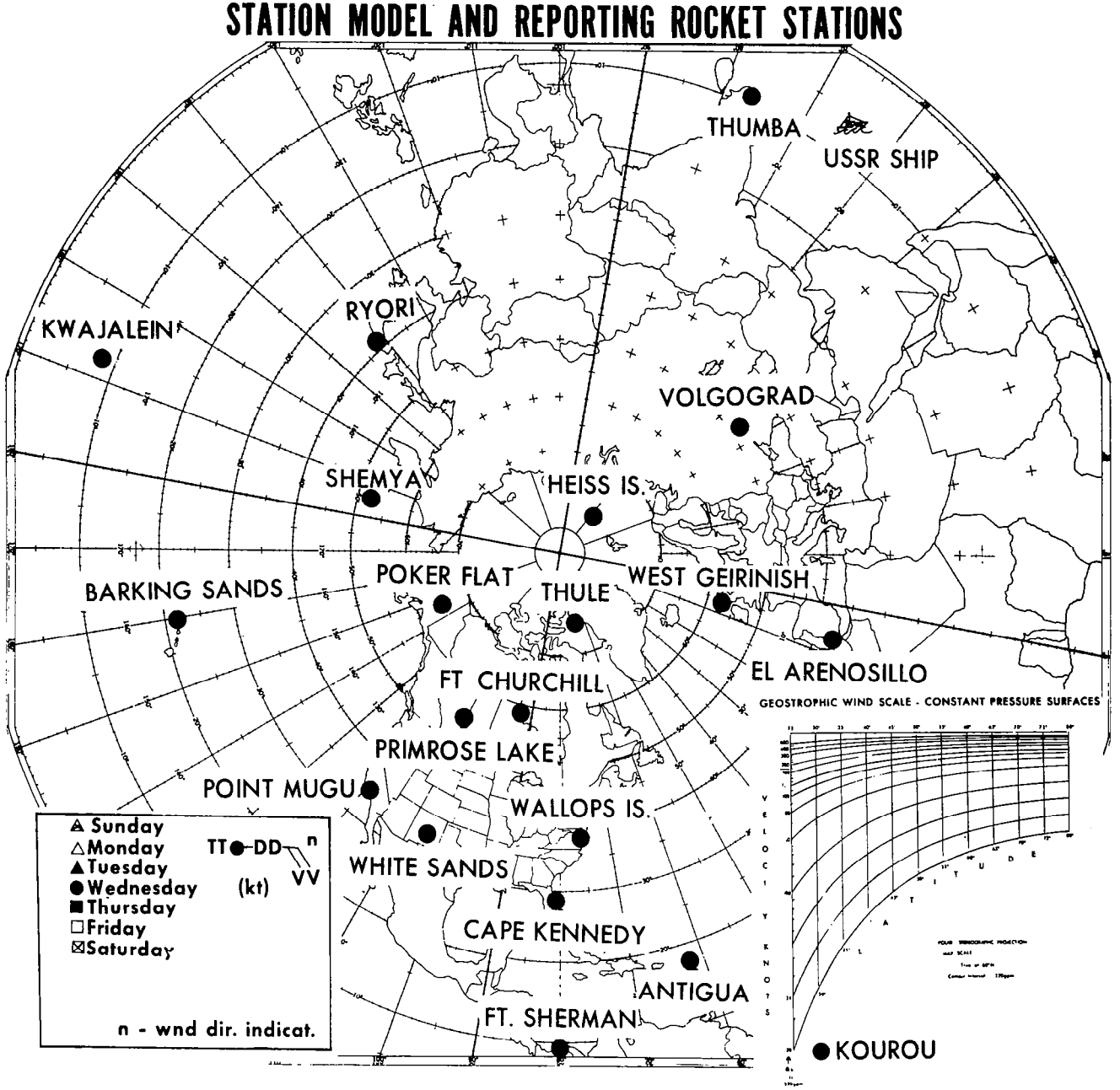
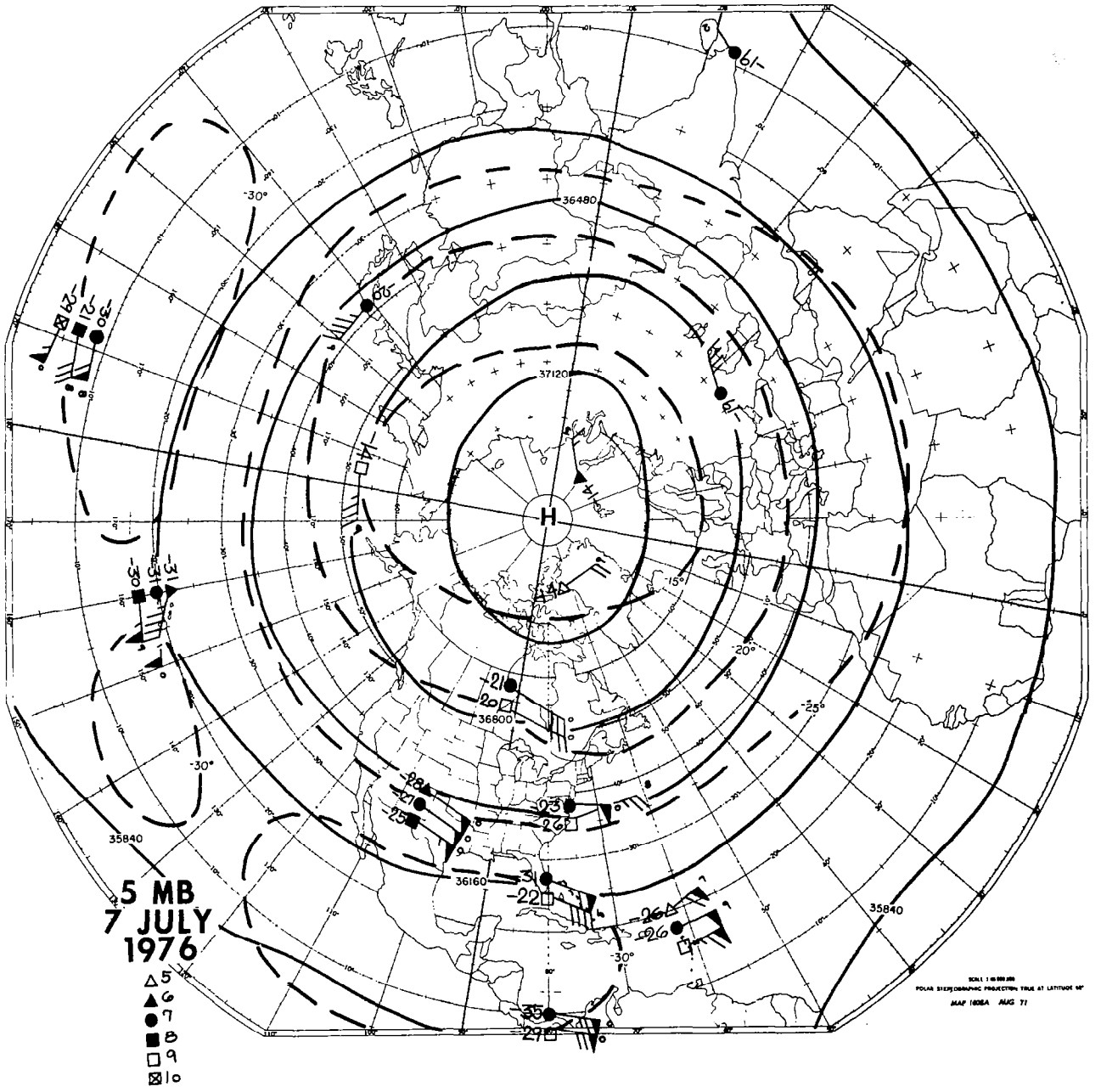


Figure 1. Northern Hemisphere map with locations of 19 rocketsonde stations and one mobile ship. Model for plotted rocketsonde data and a geostrophic wind scale are also shown.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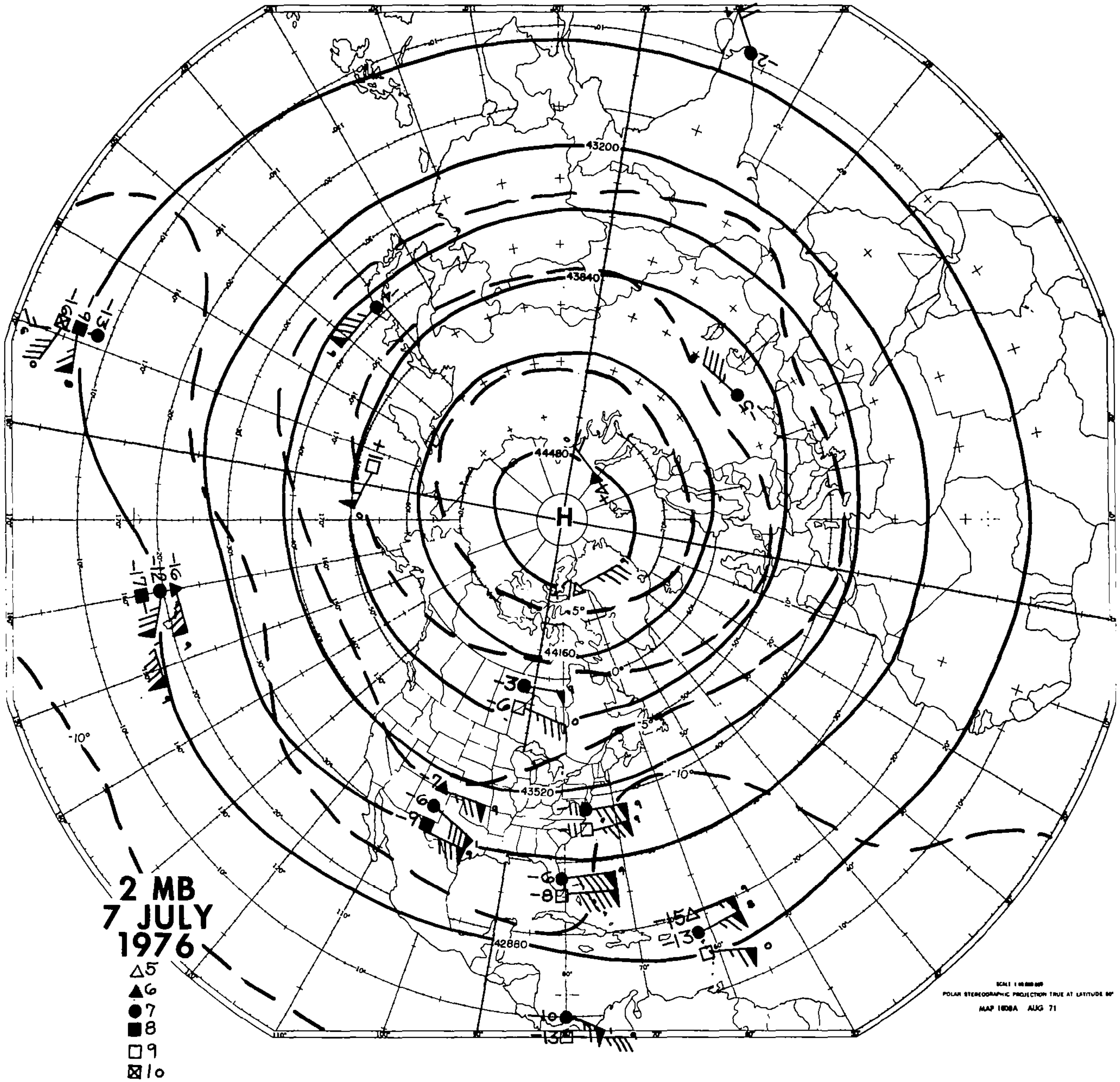
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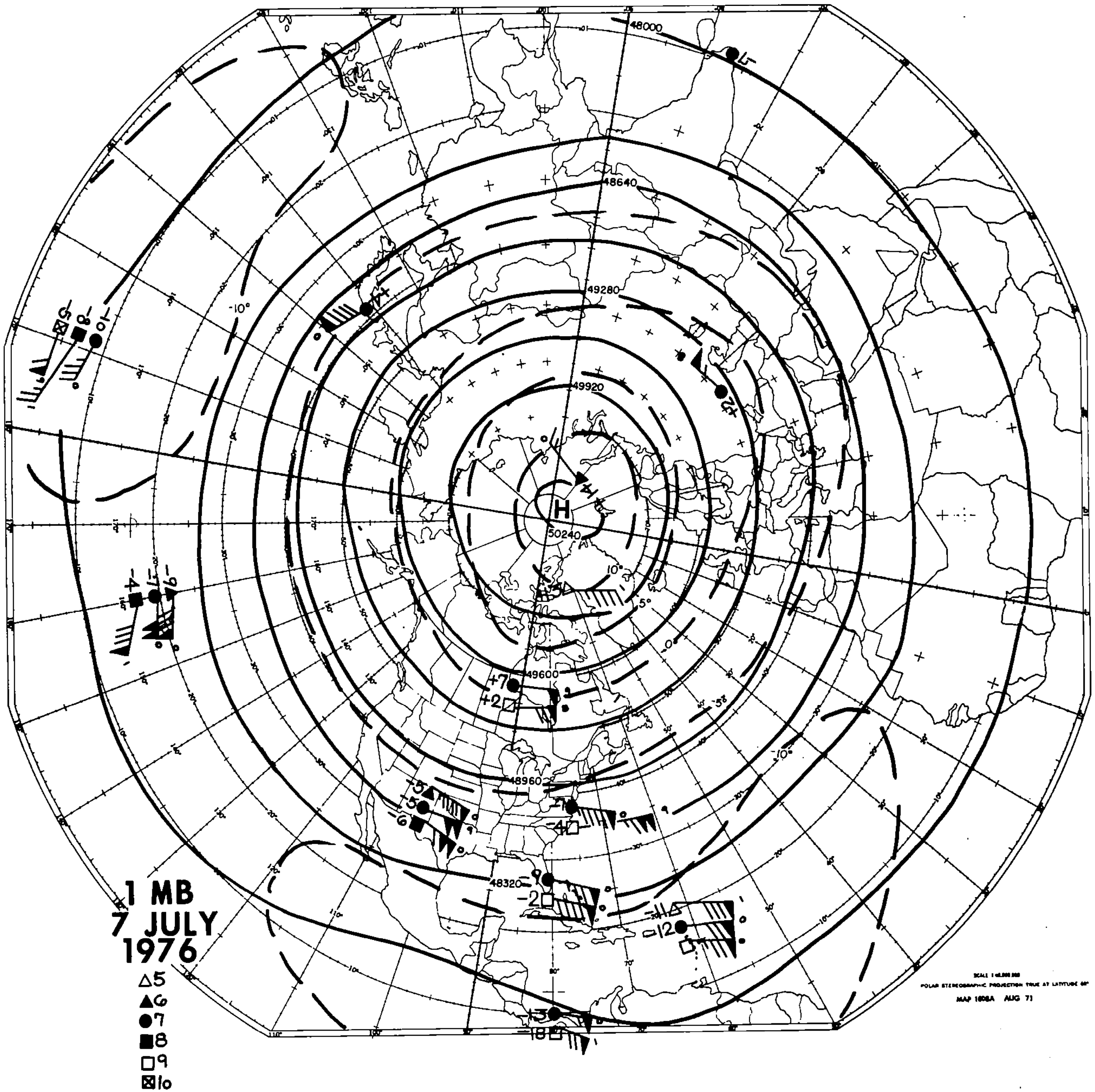
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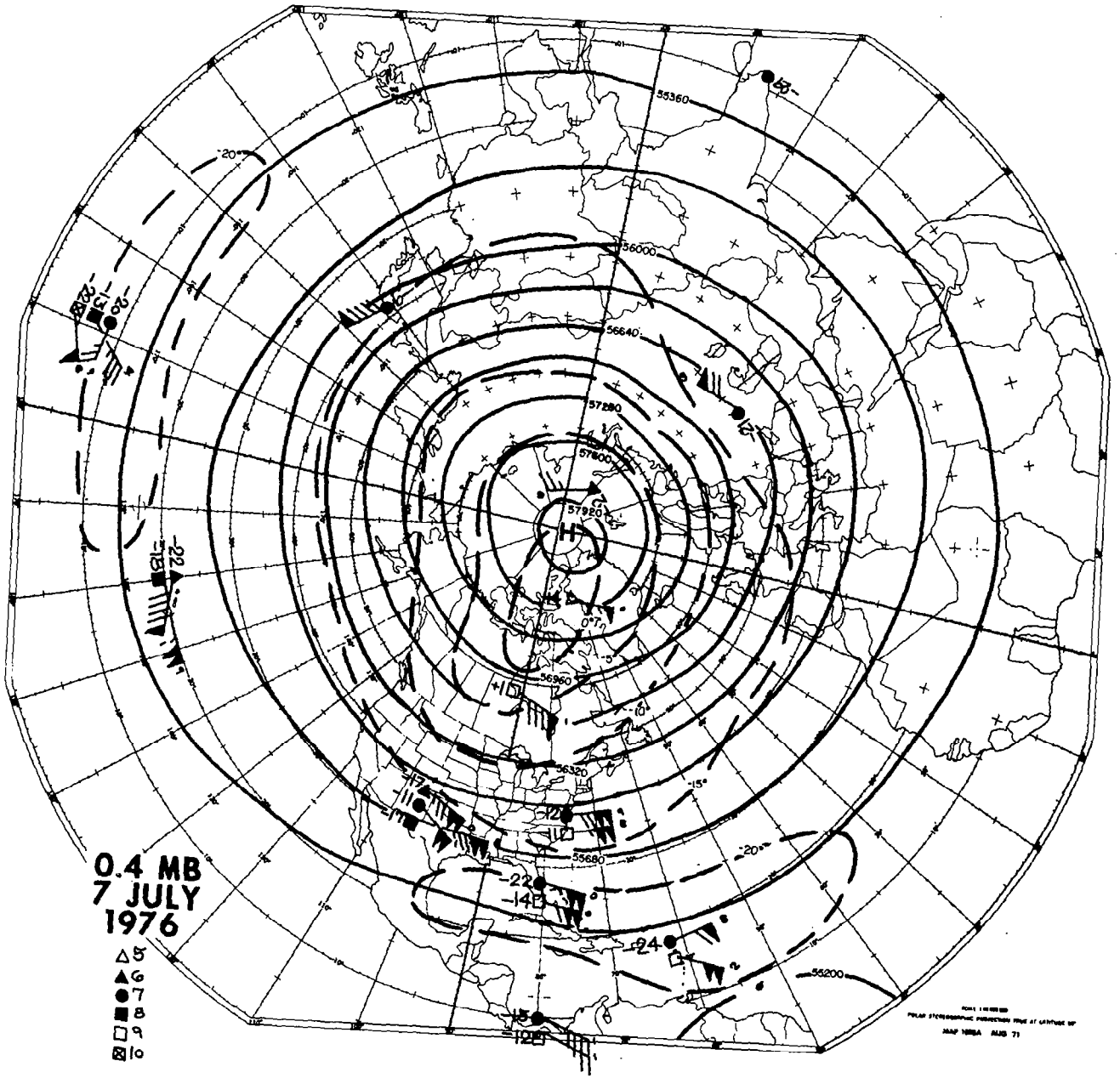
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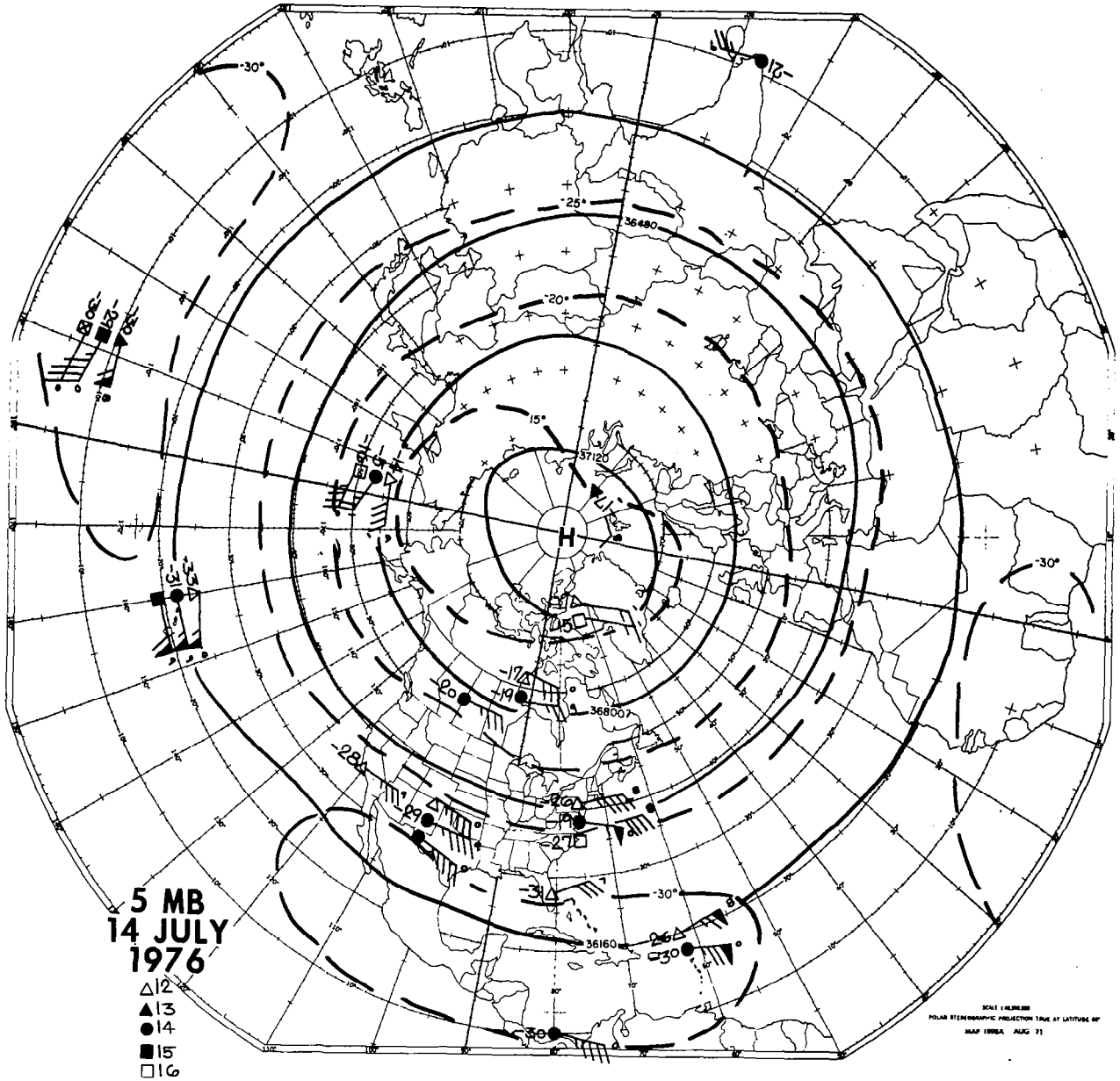
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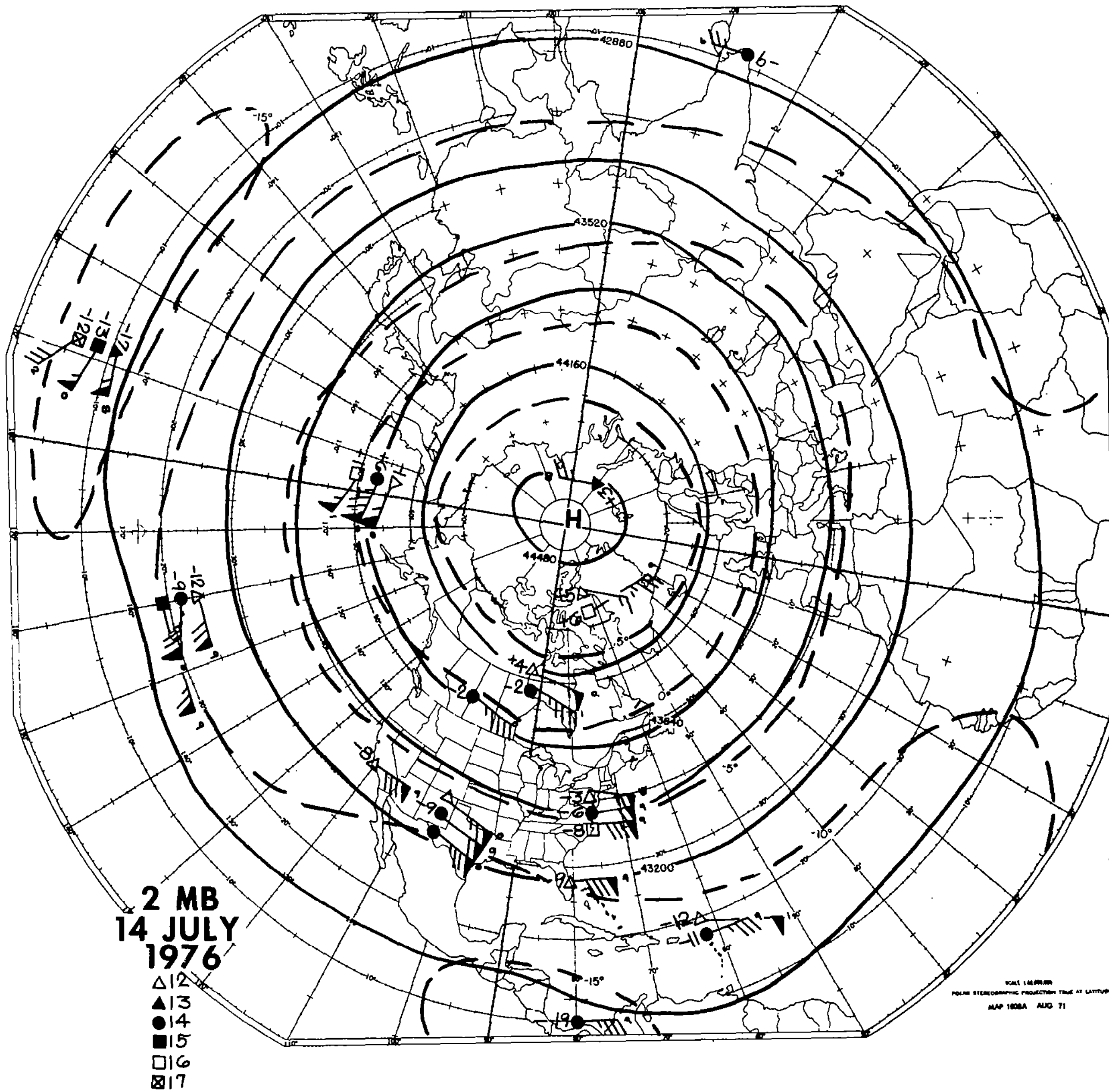
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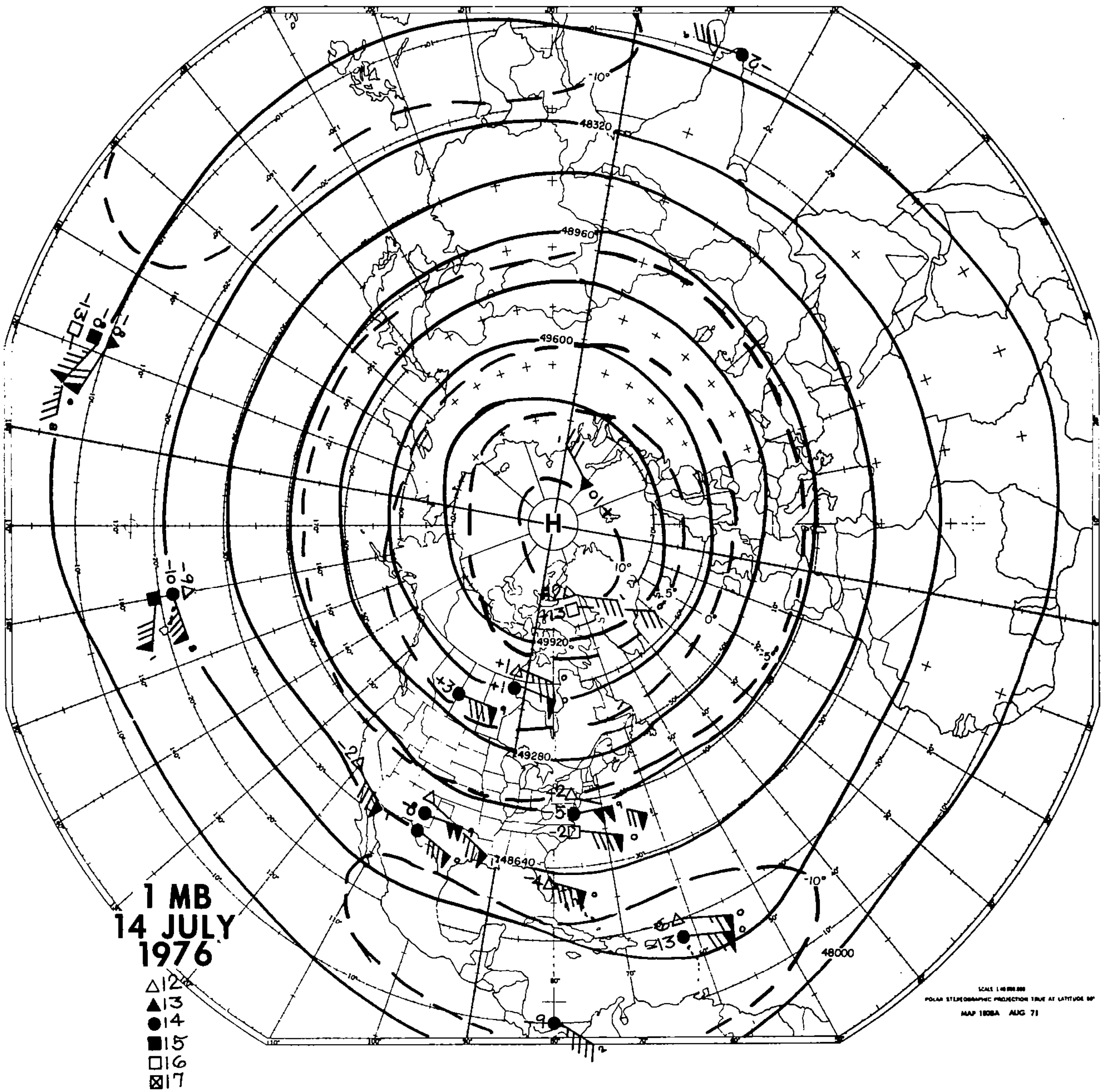
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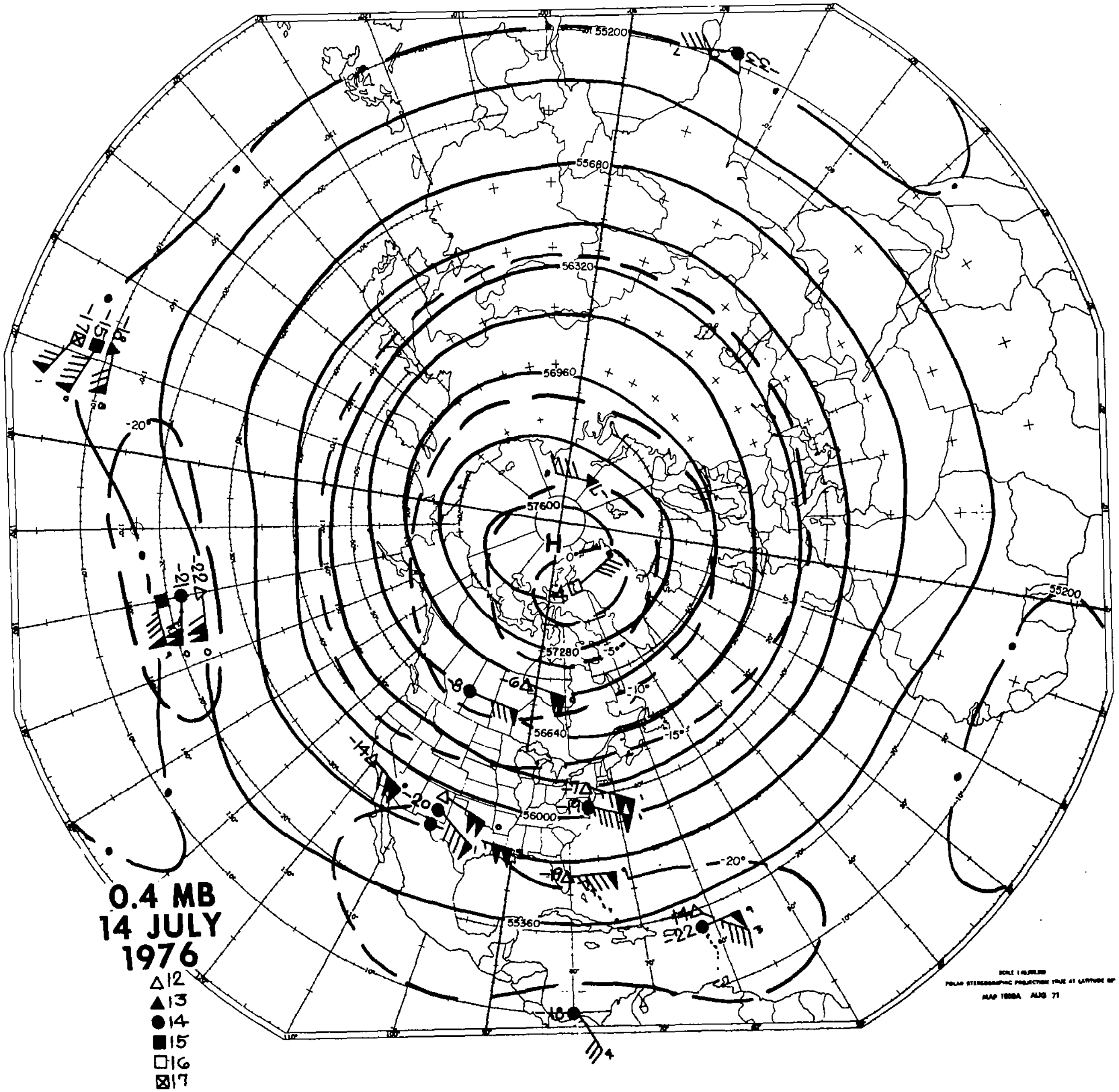
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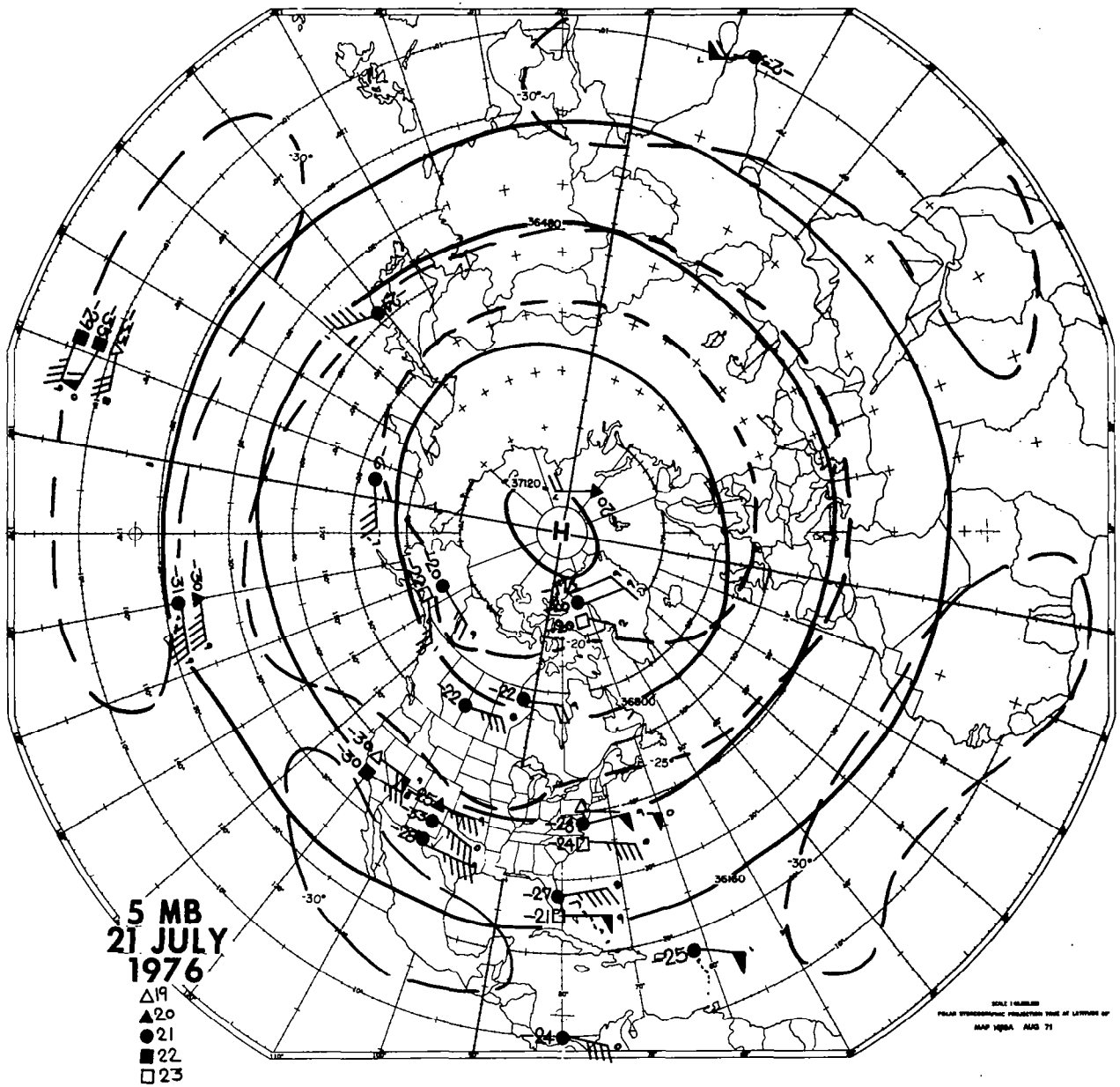
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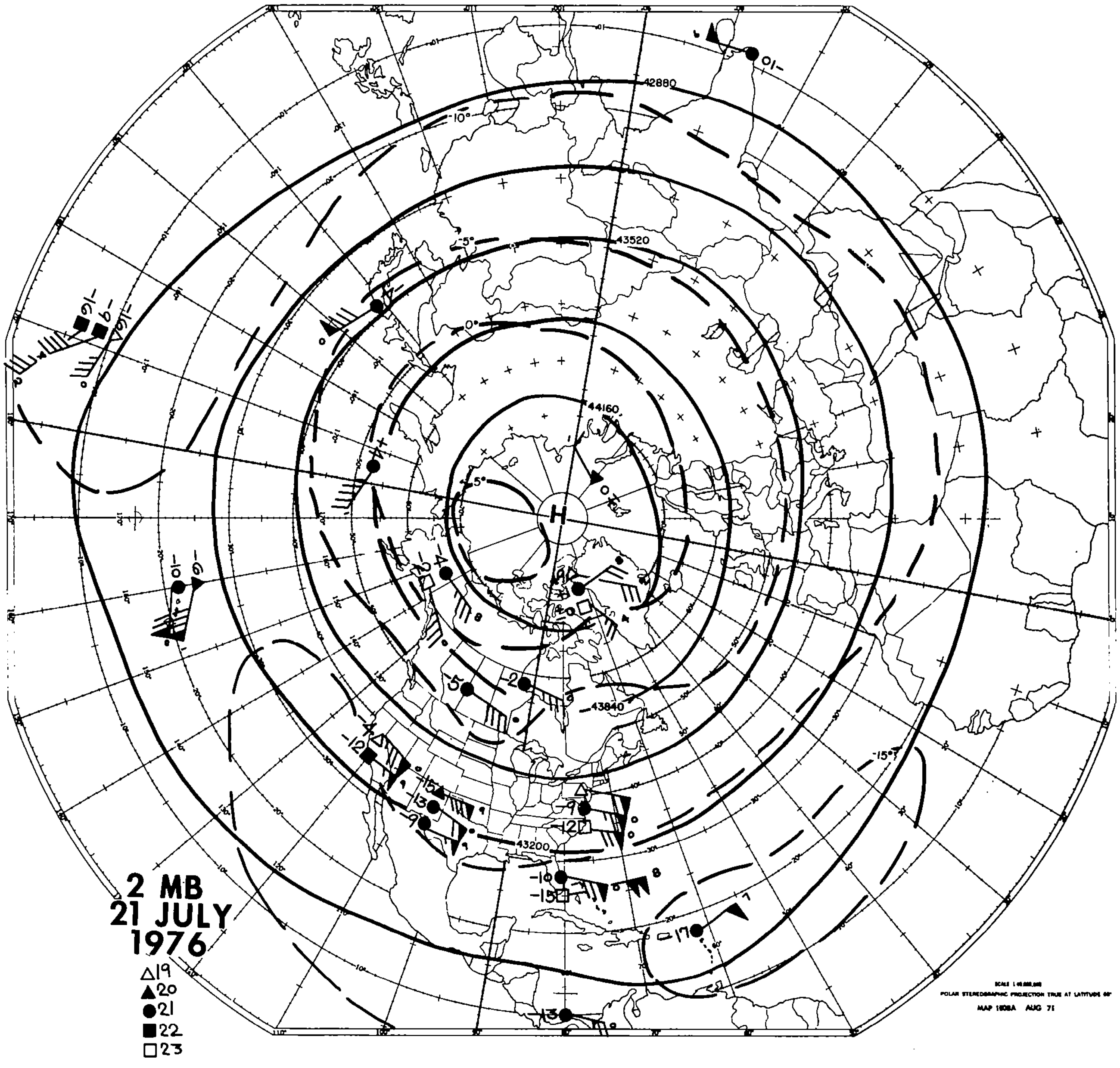

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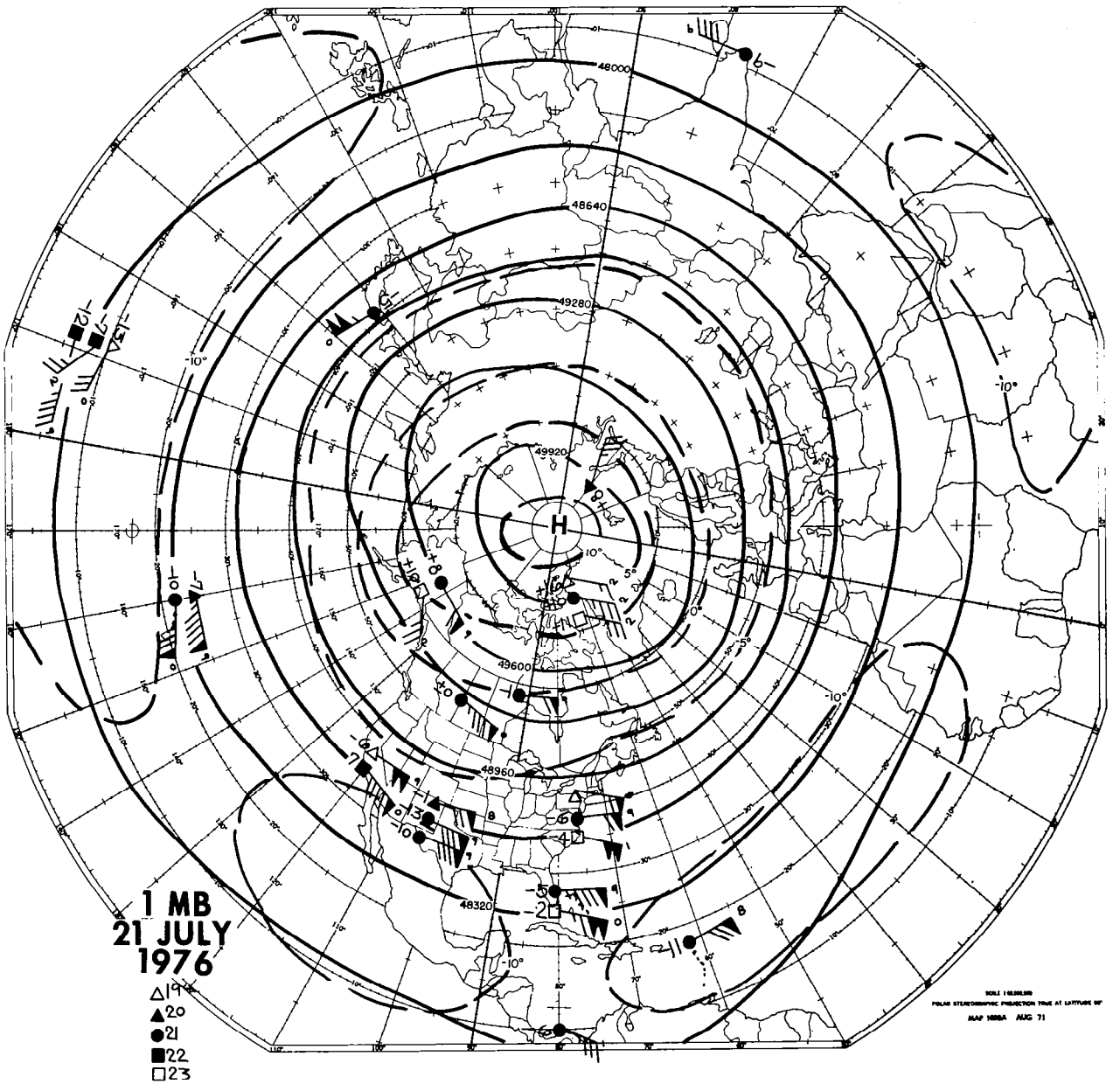
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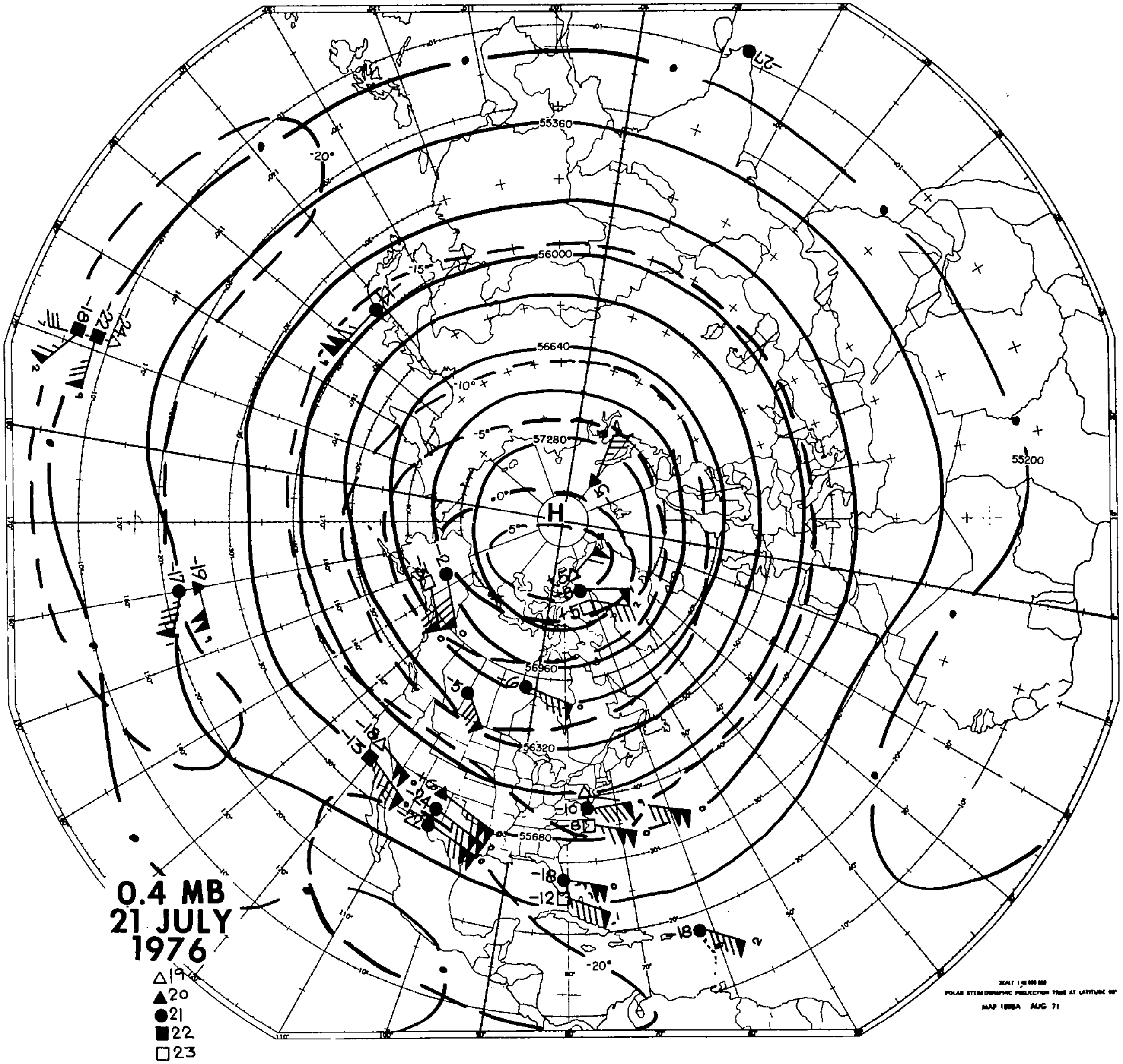
MAP NH8A AUG 71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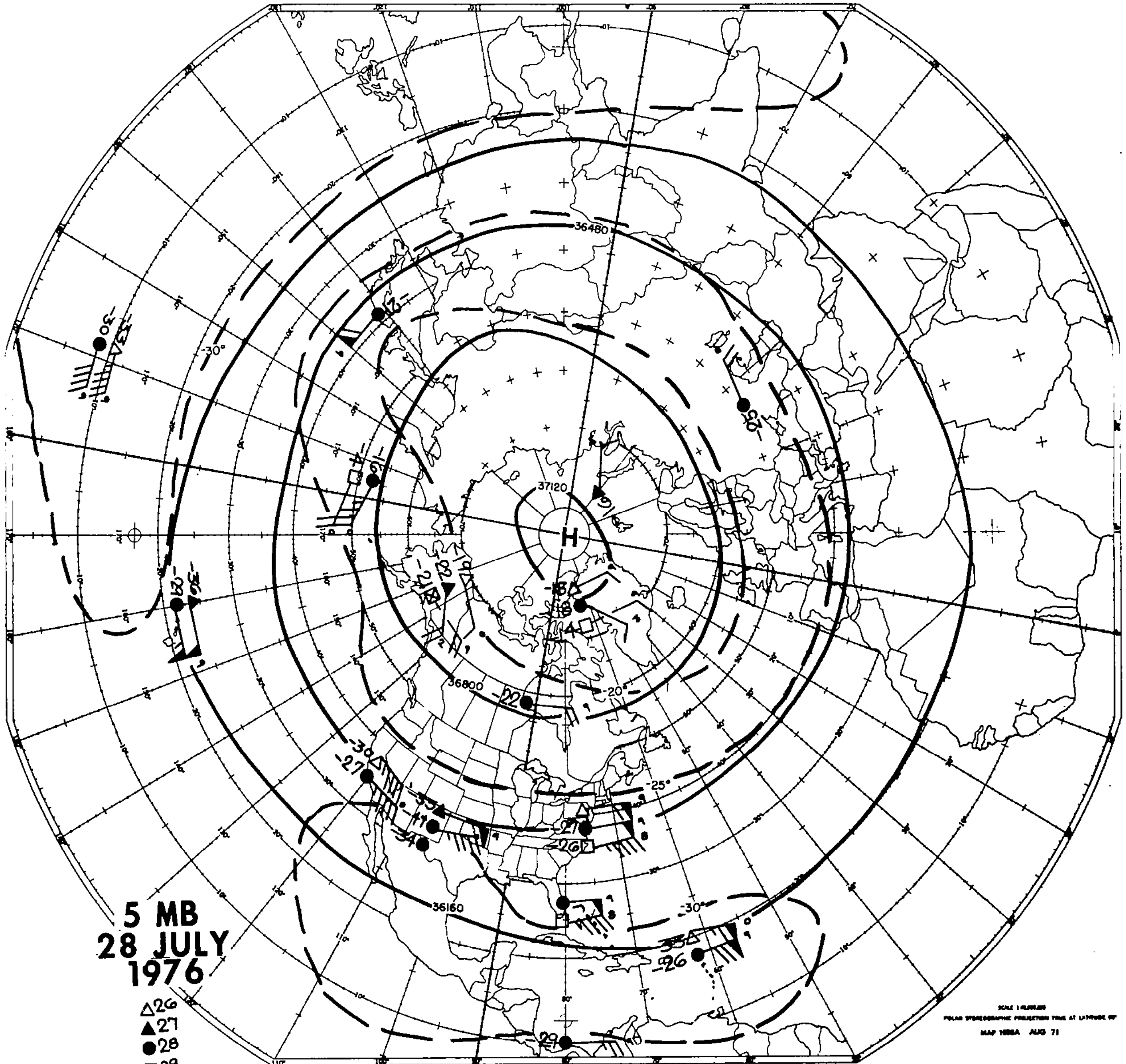

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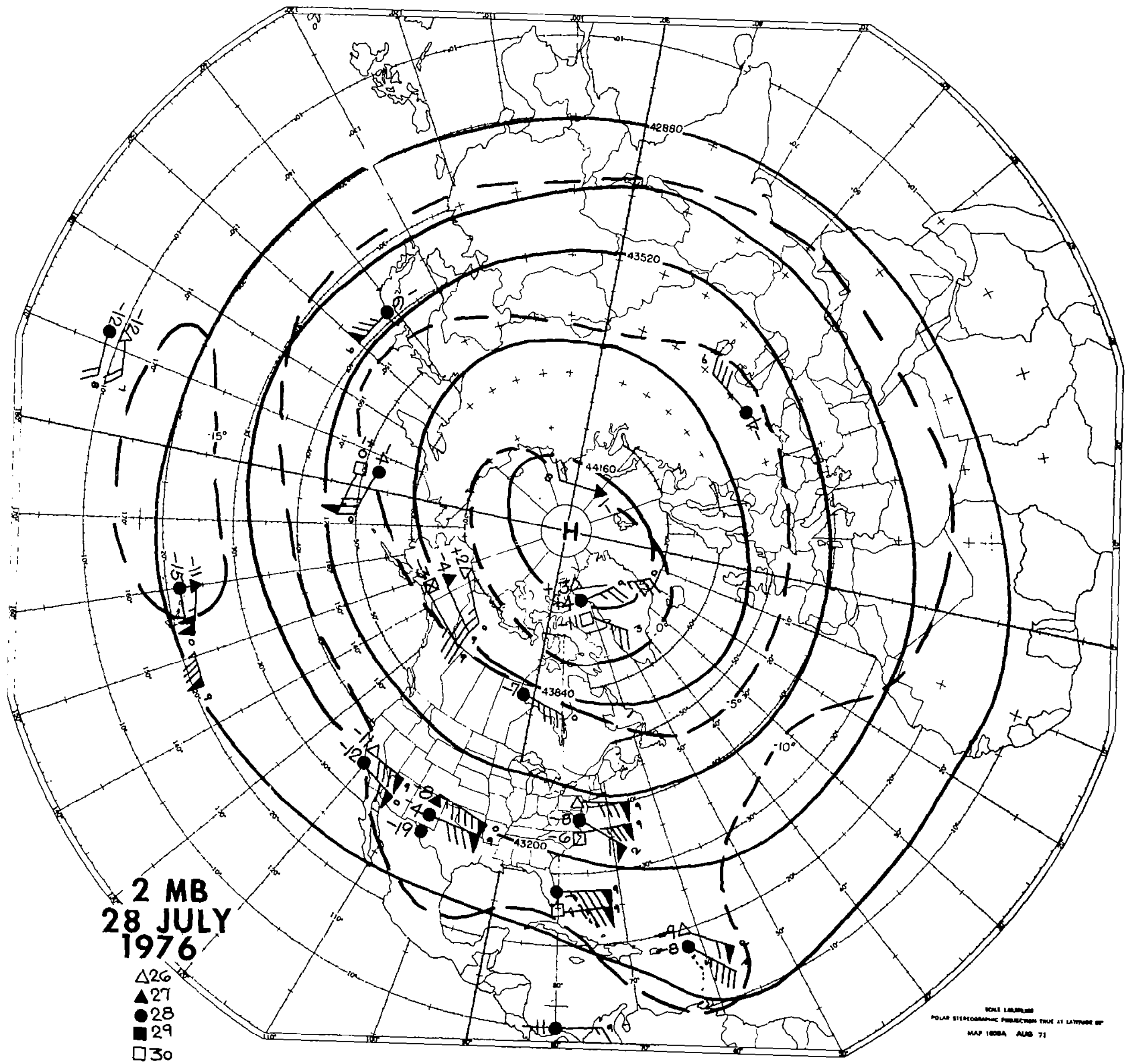

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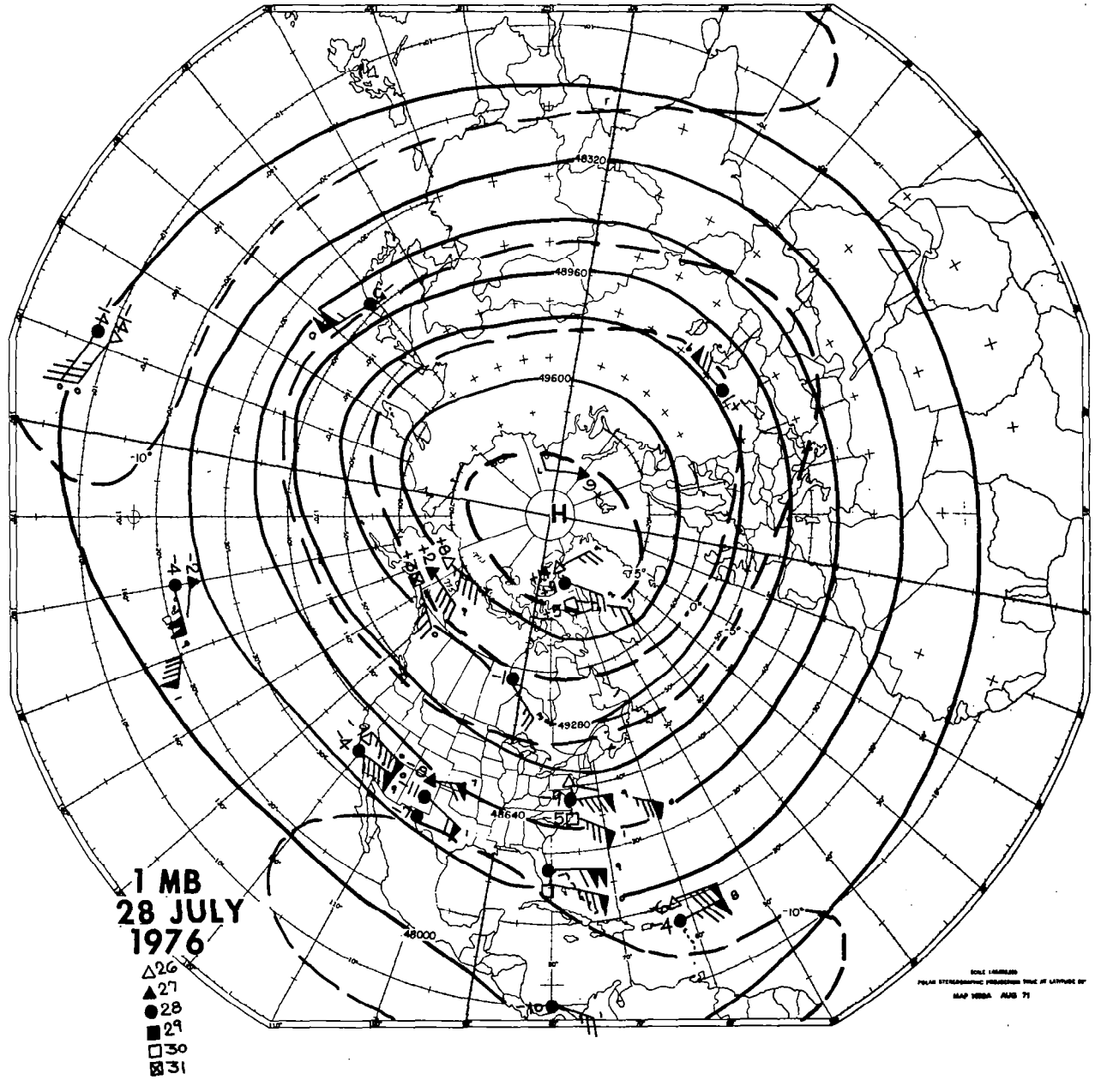
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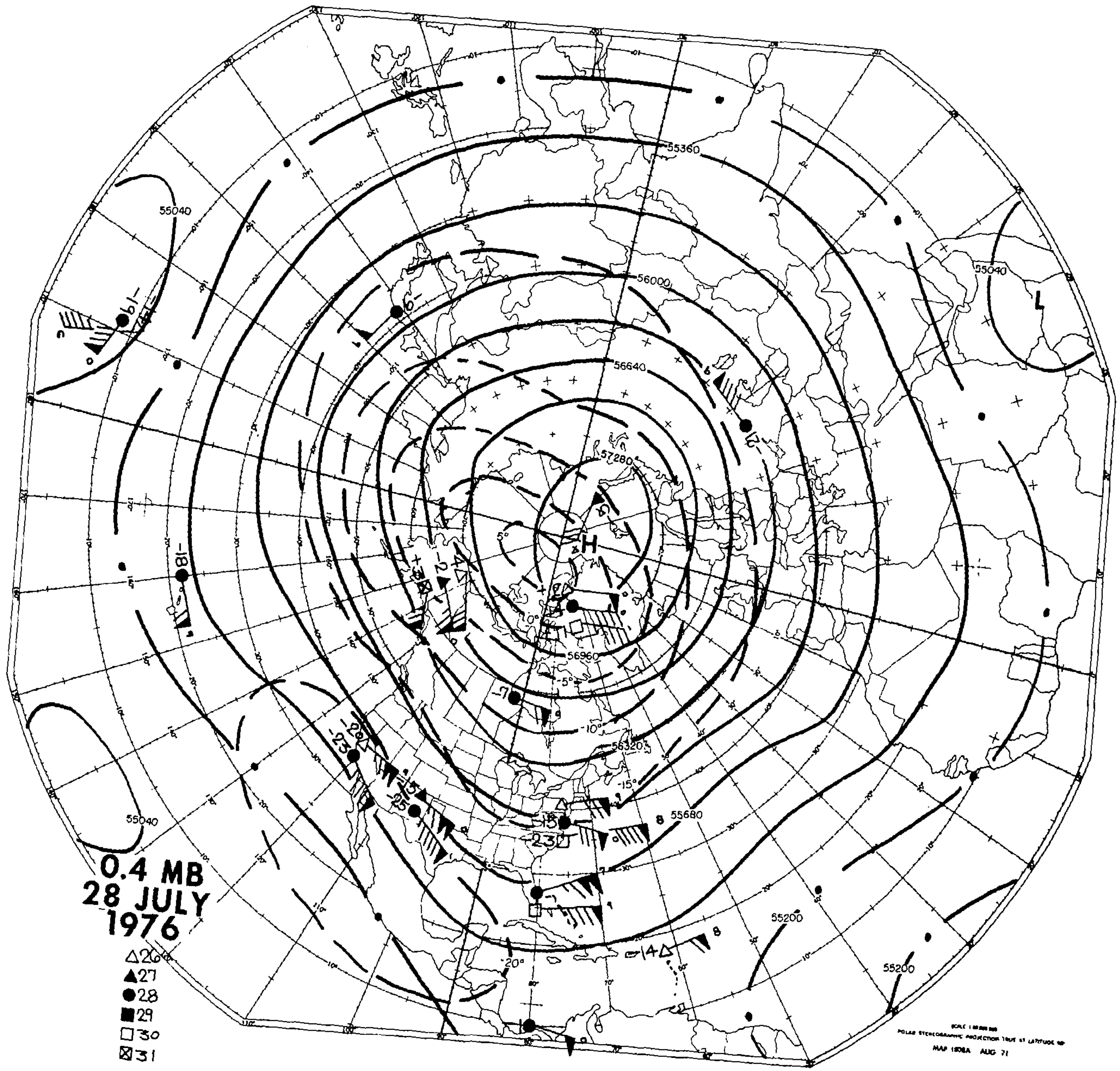
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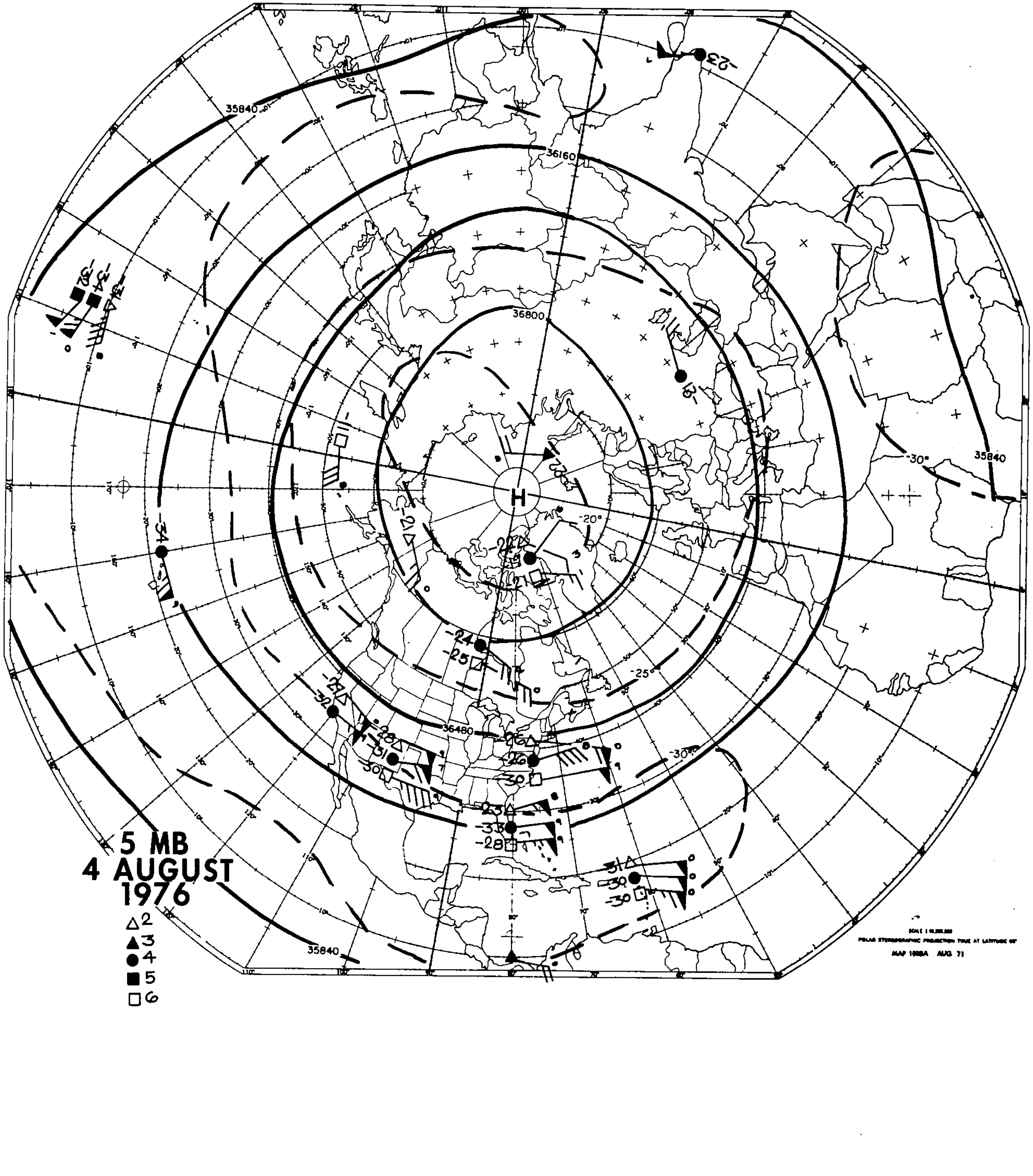
MAP 1108A AUG 71
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°



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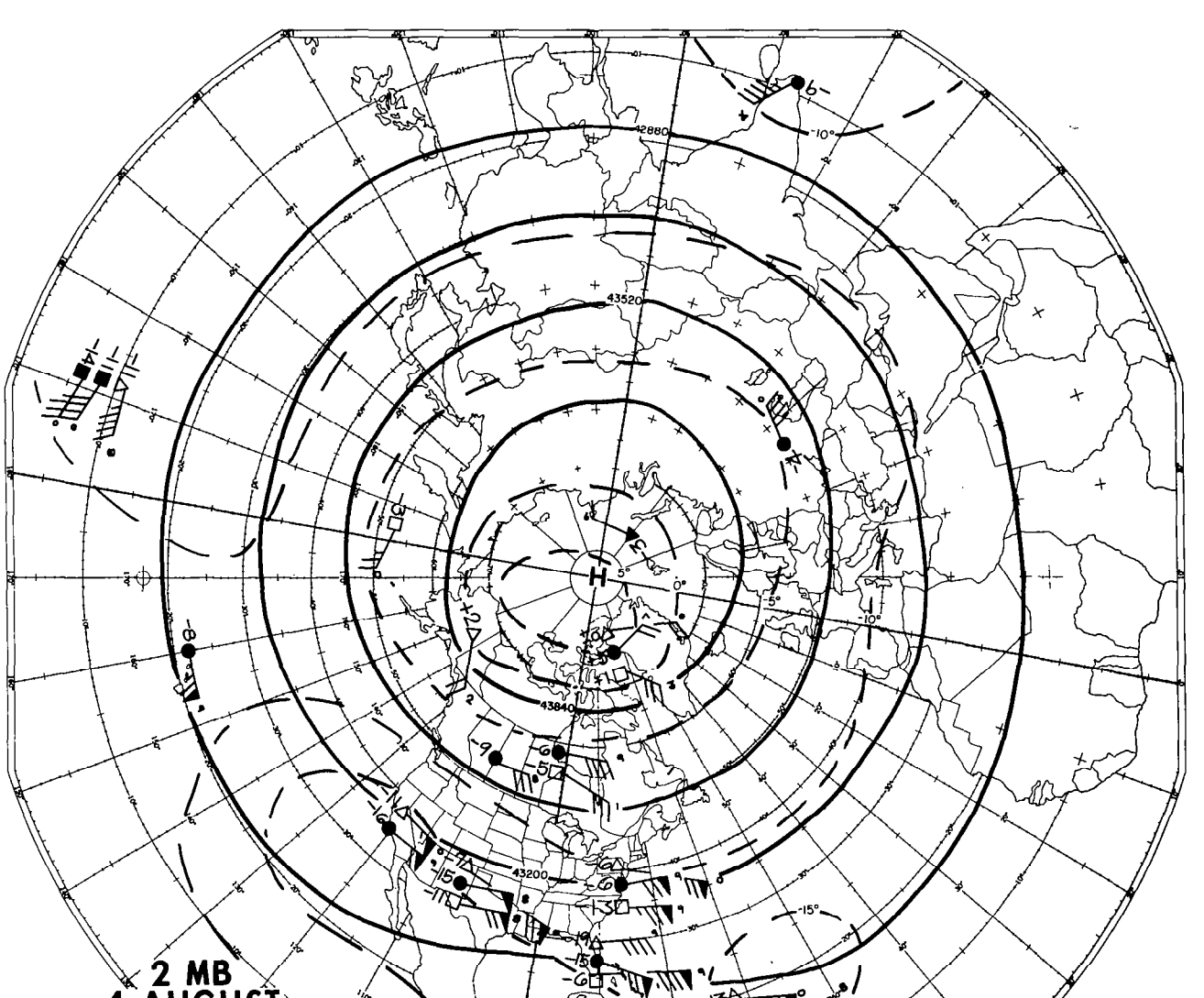
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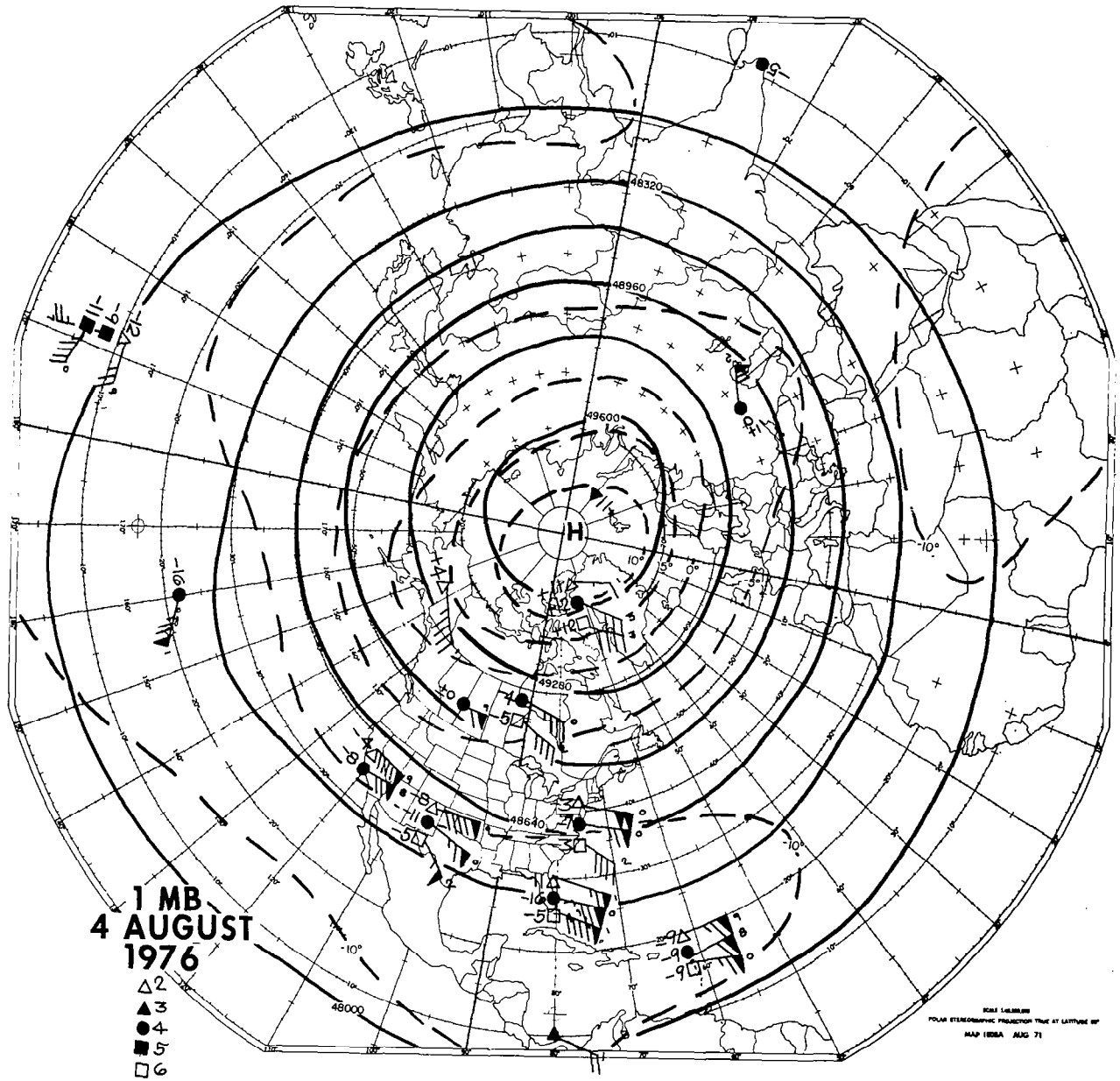
MAP 1808A AUG 71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■5
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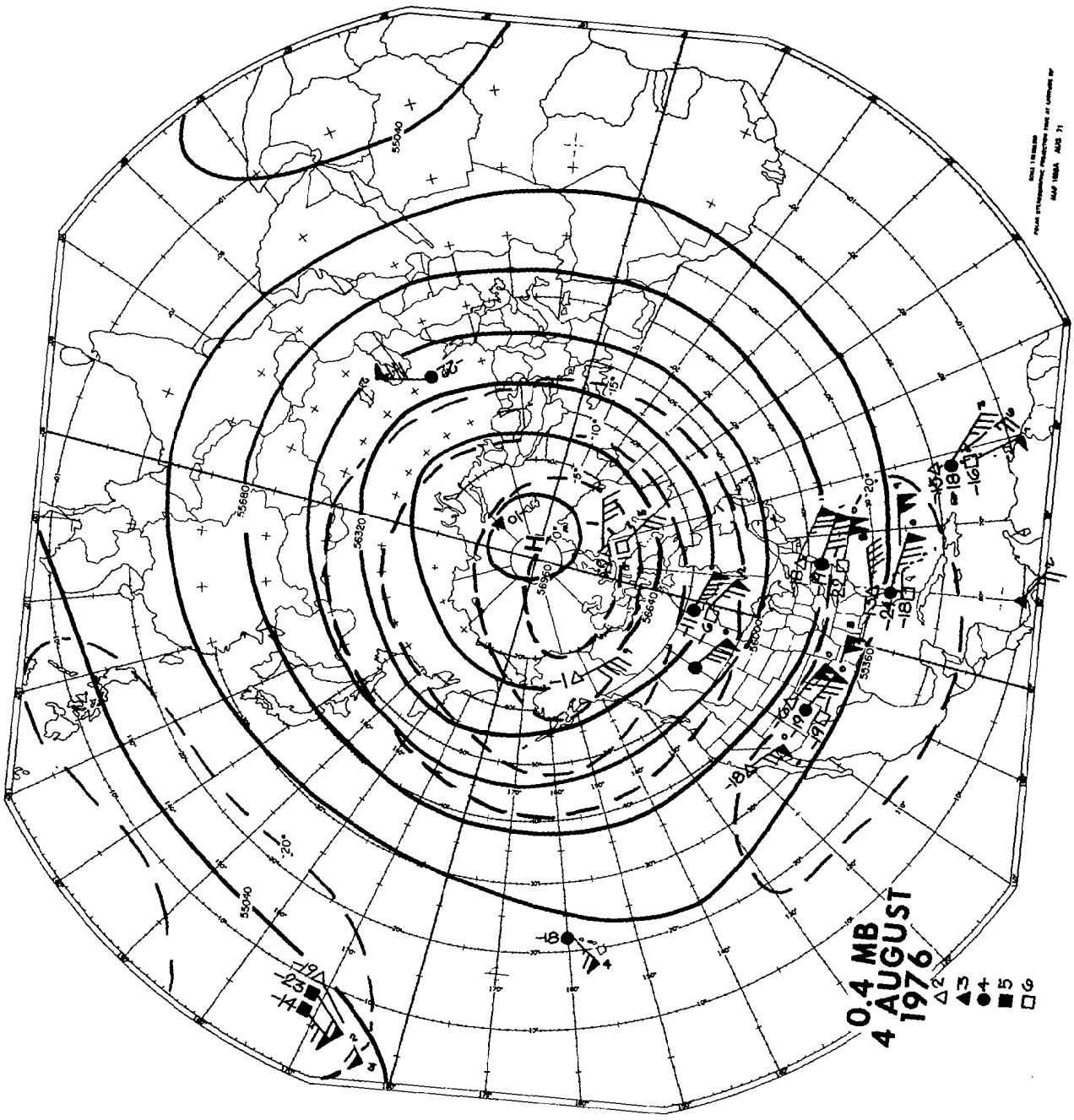
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1808A AUG 71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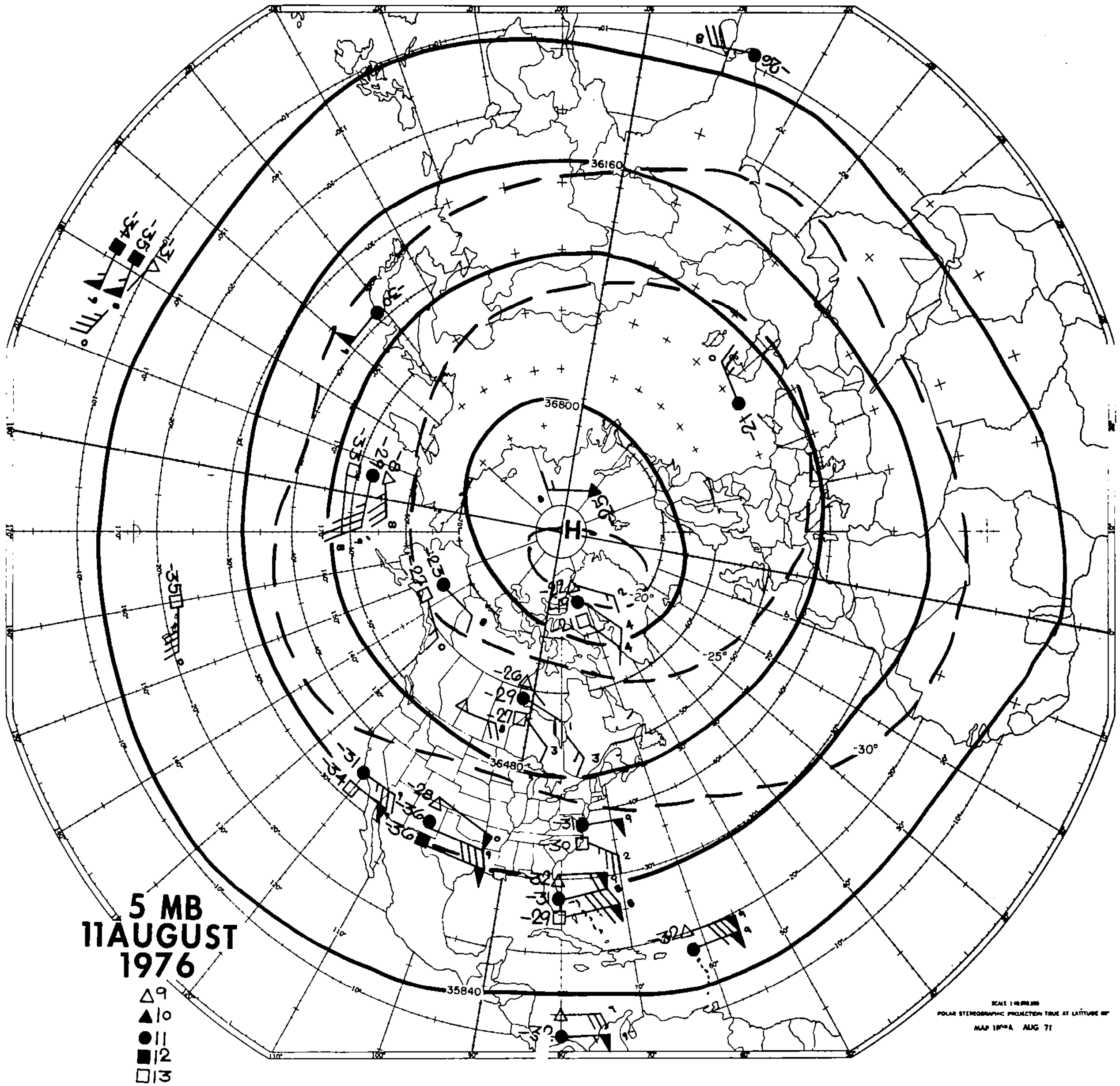
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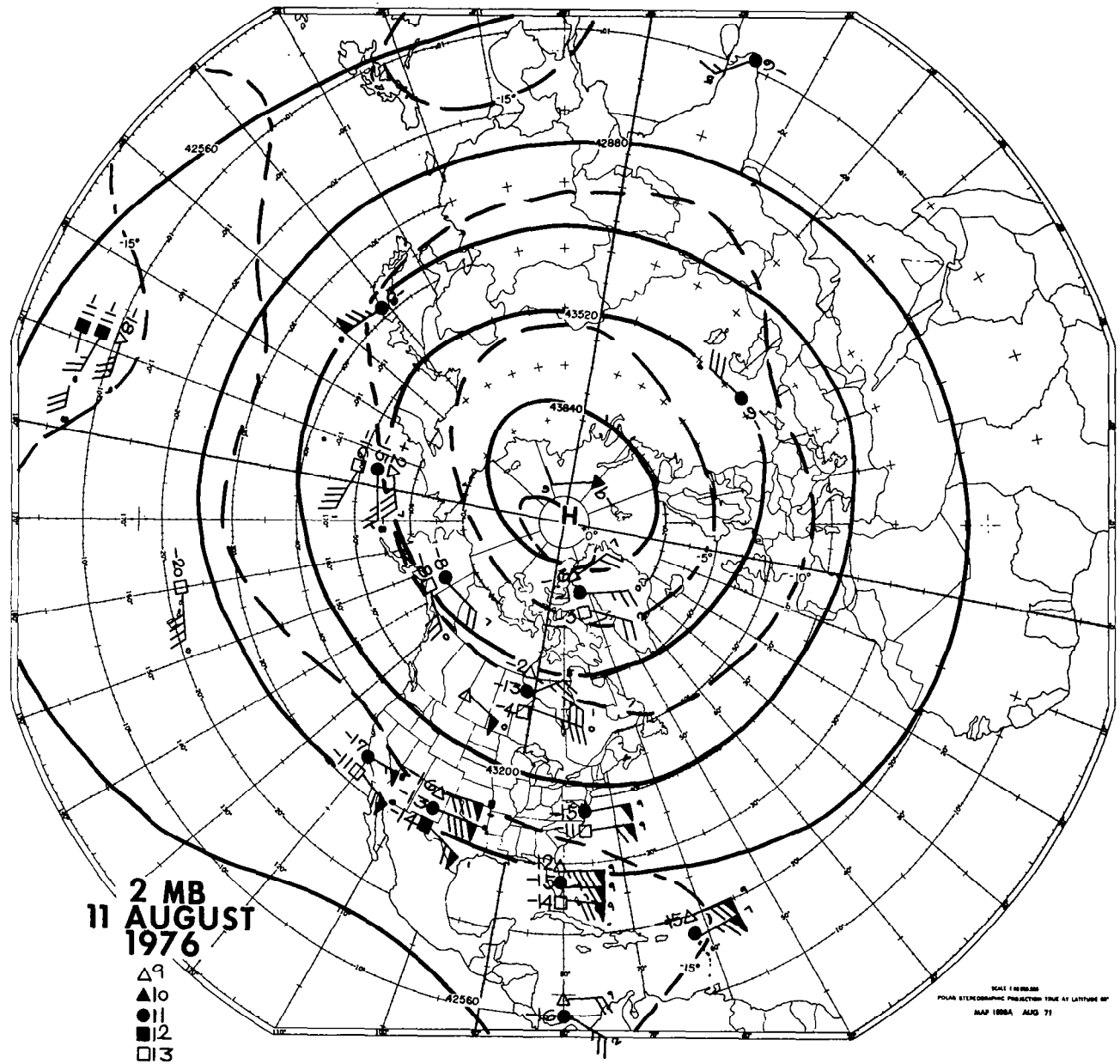
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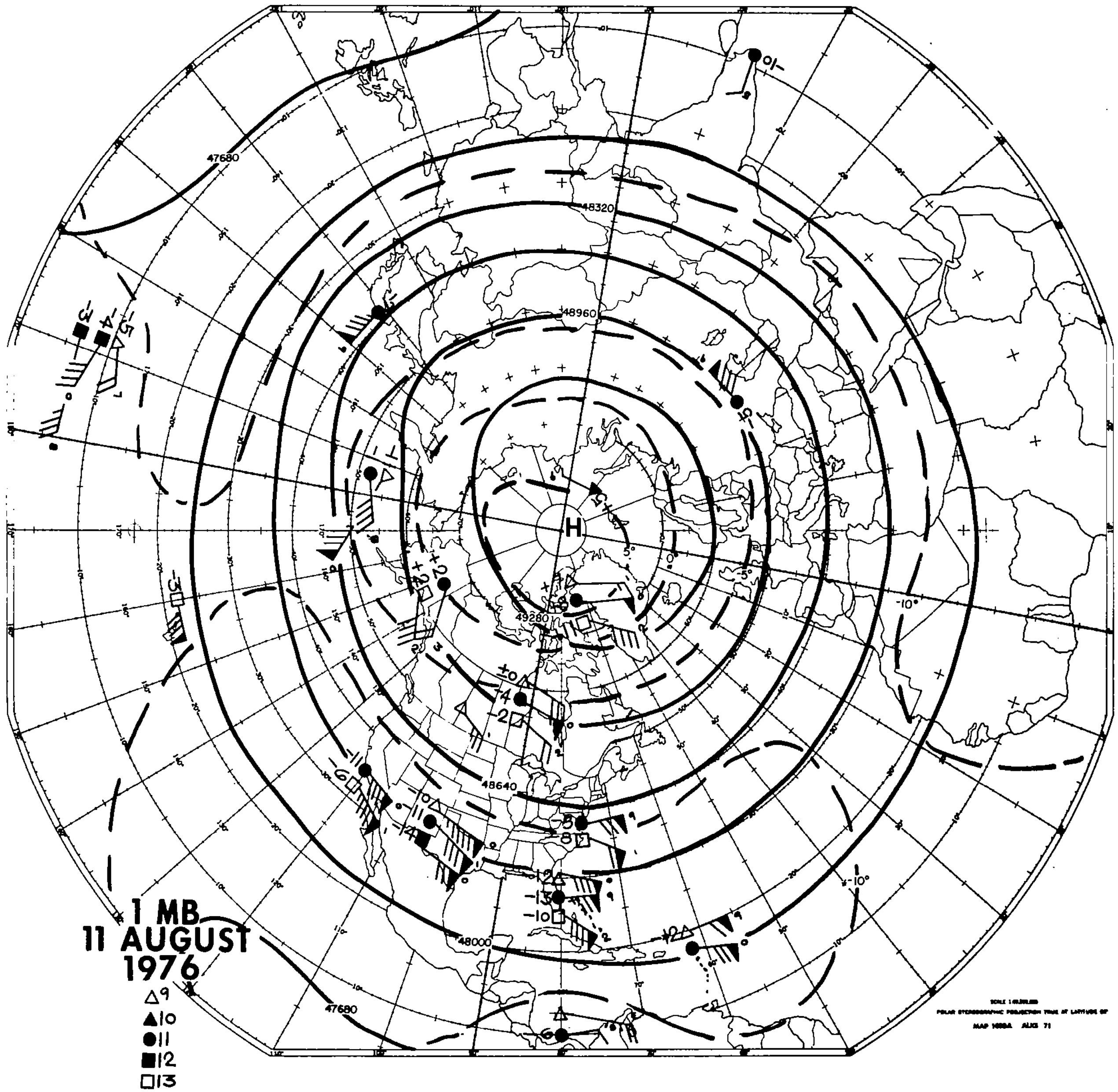
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1008A AUG 71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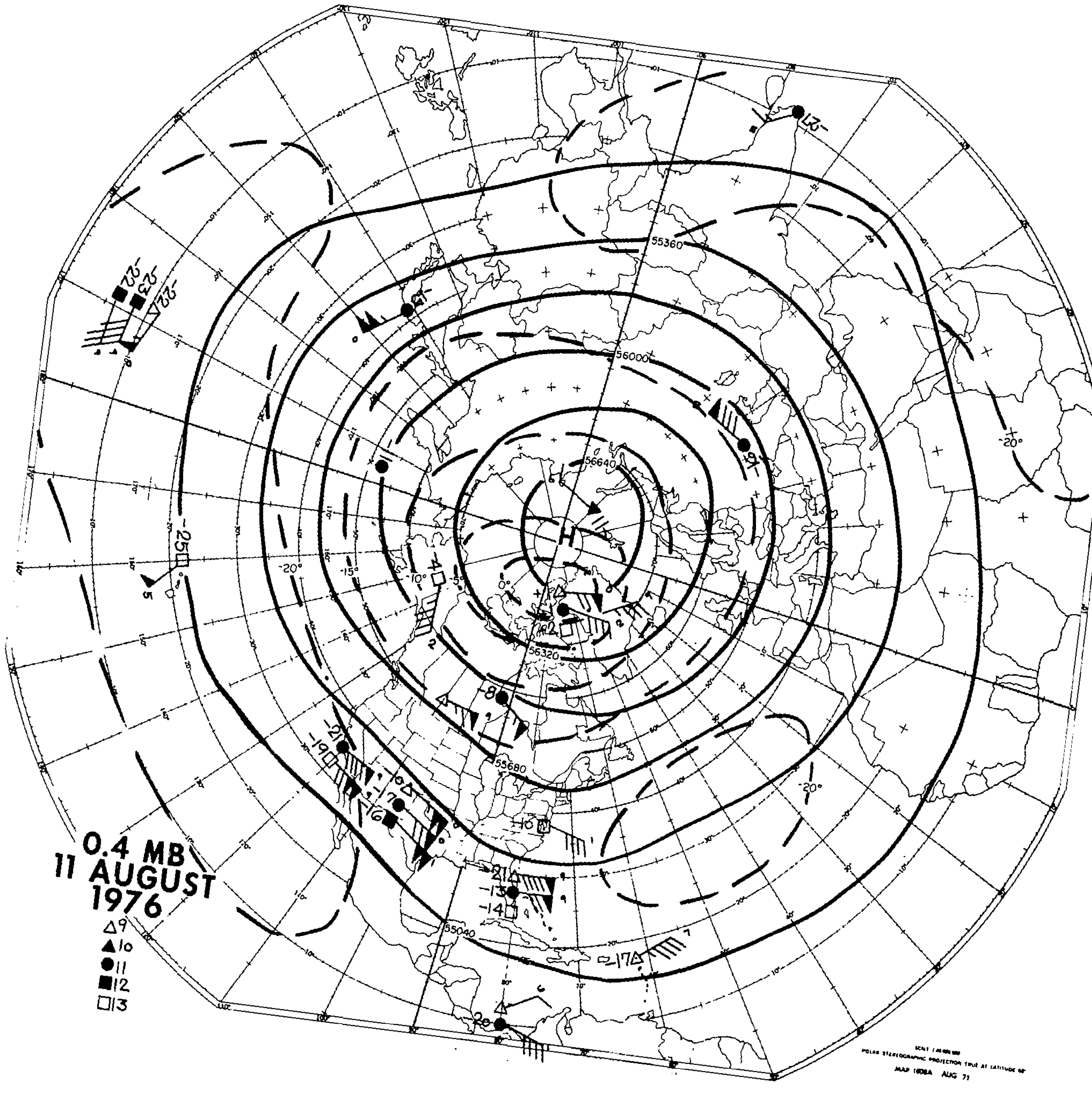
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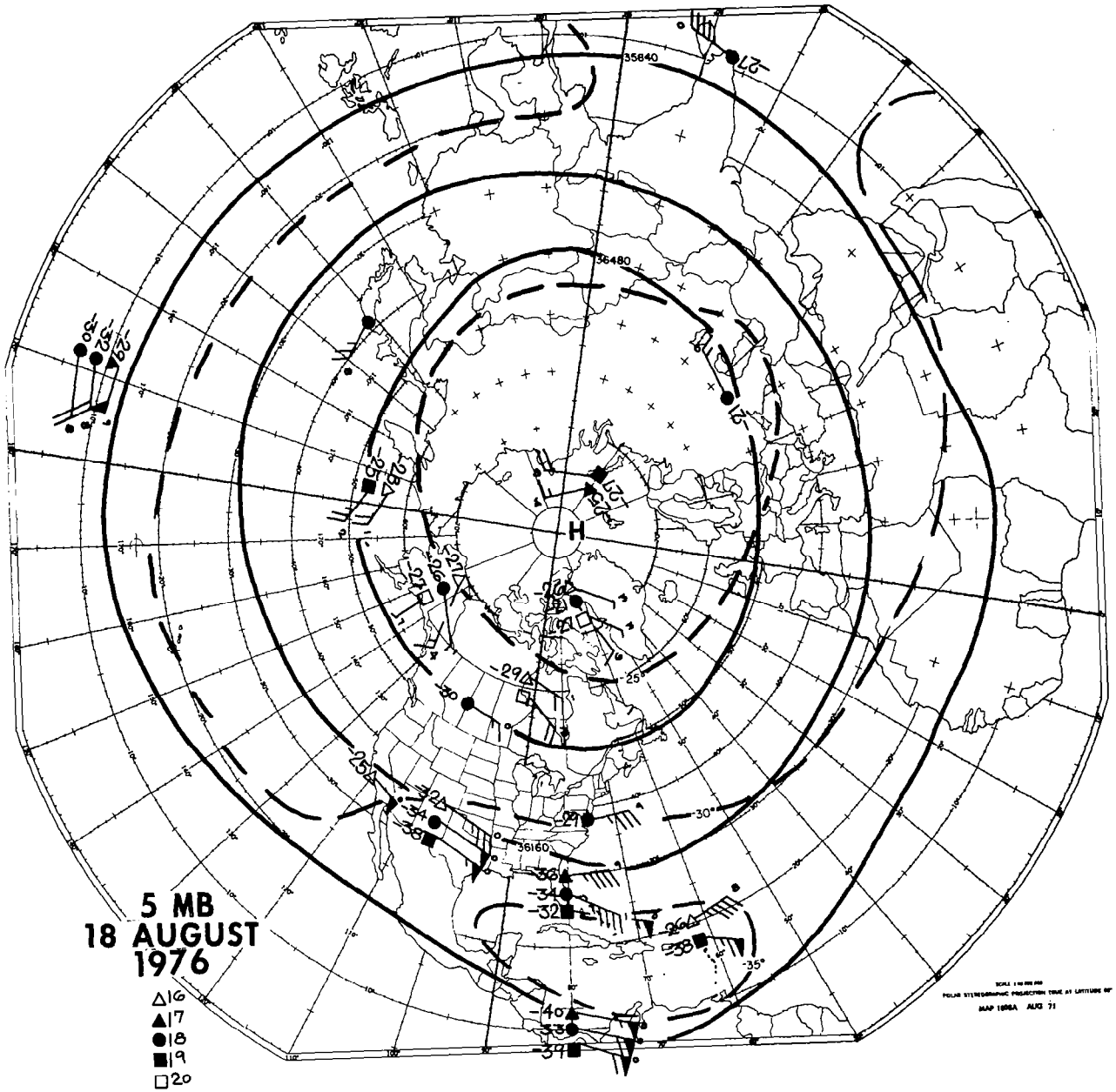
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1608A AUG 71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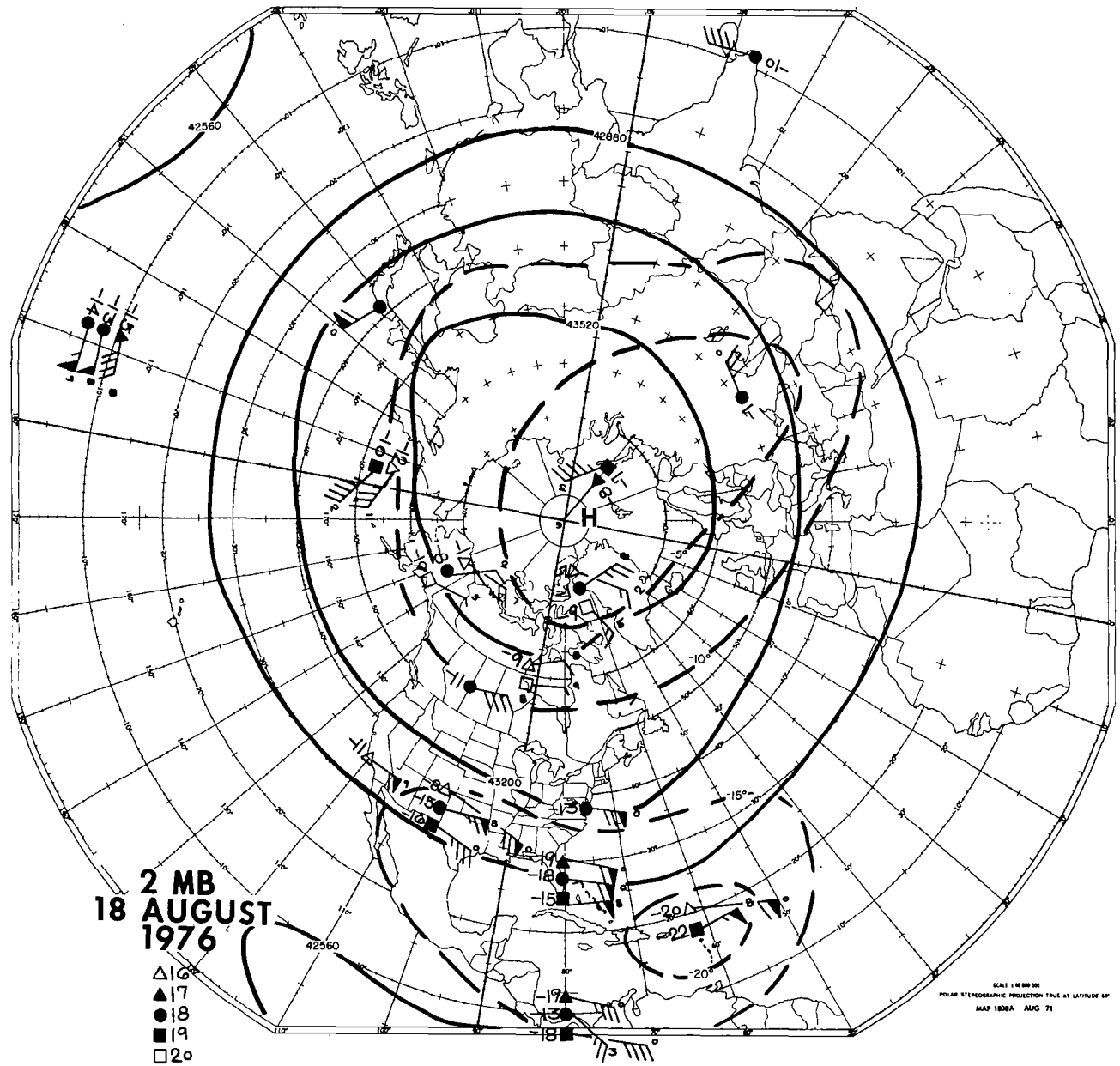
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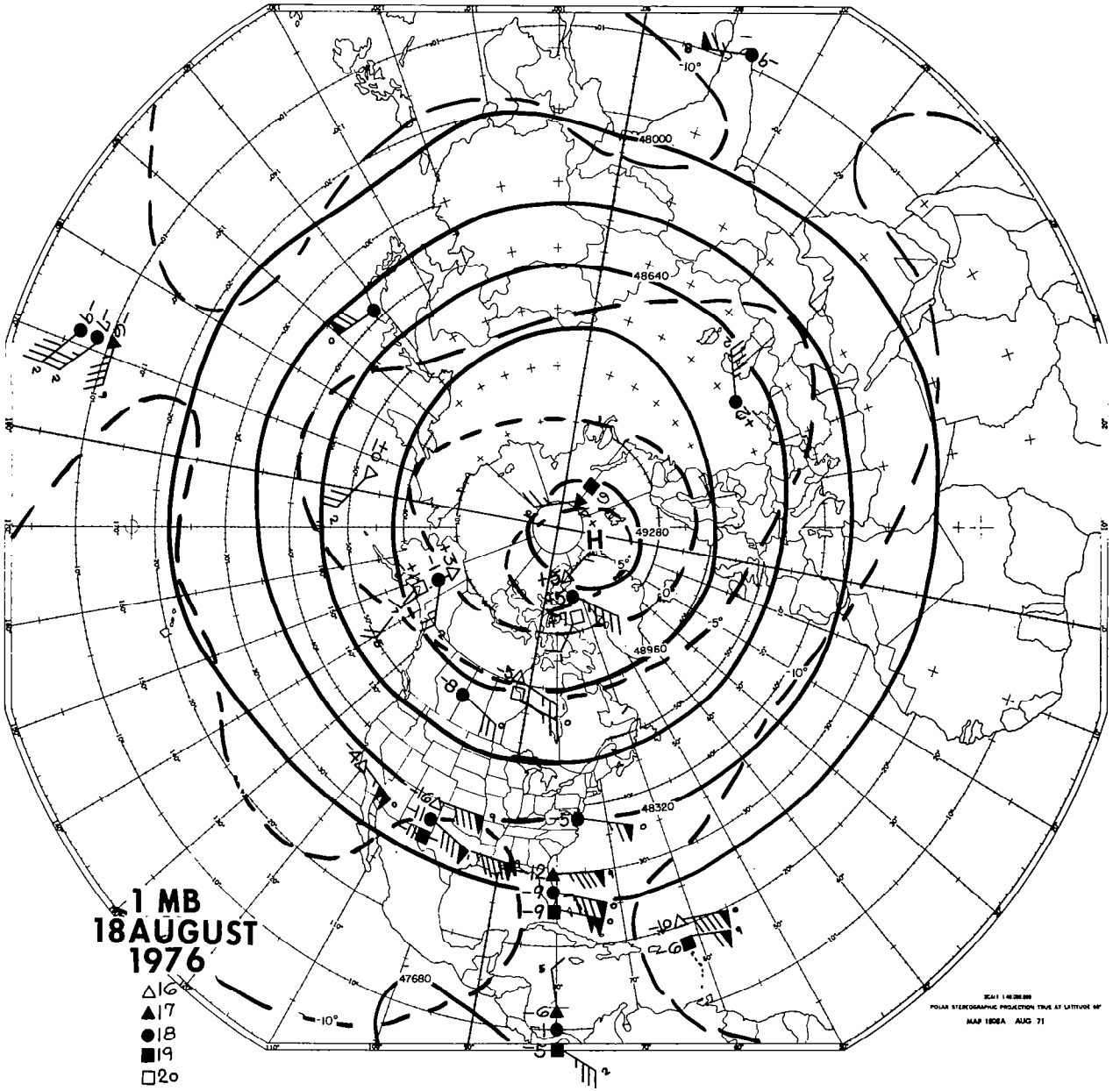
MAP 1808A AUG 71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10°
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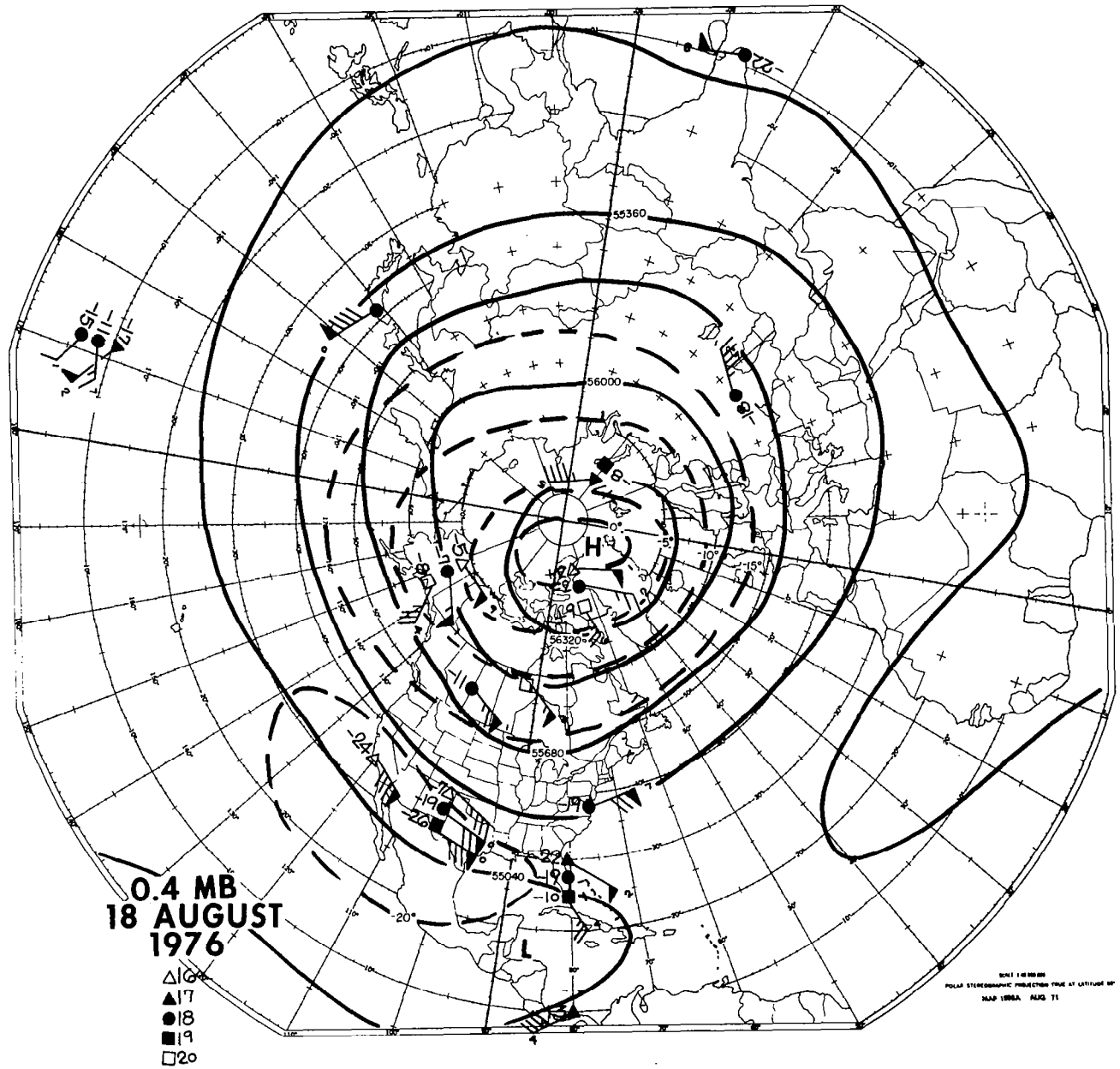
MAP 1606A AUG 71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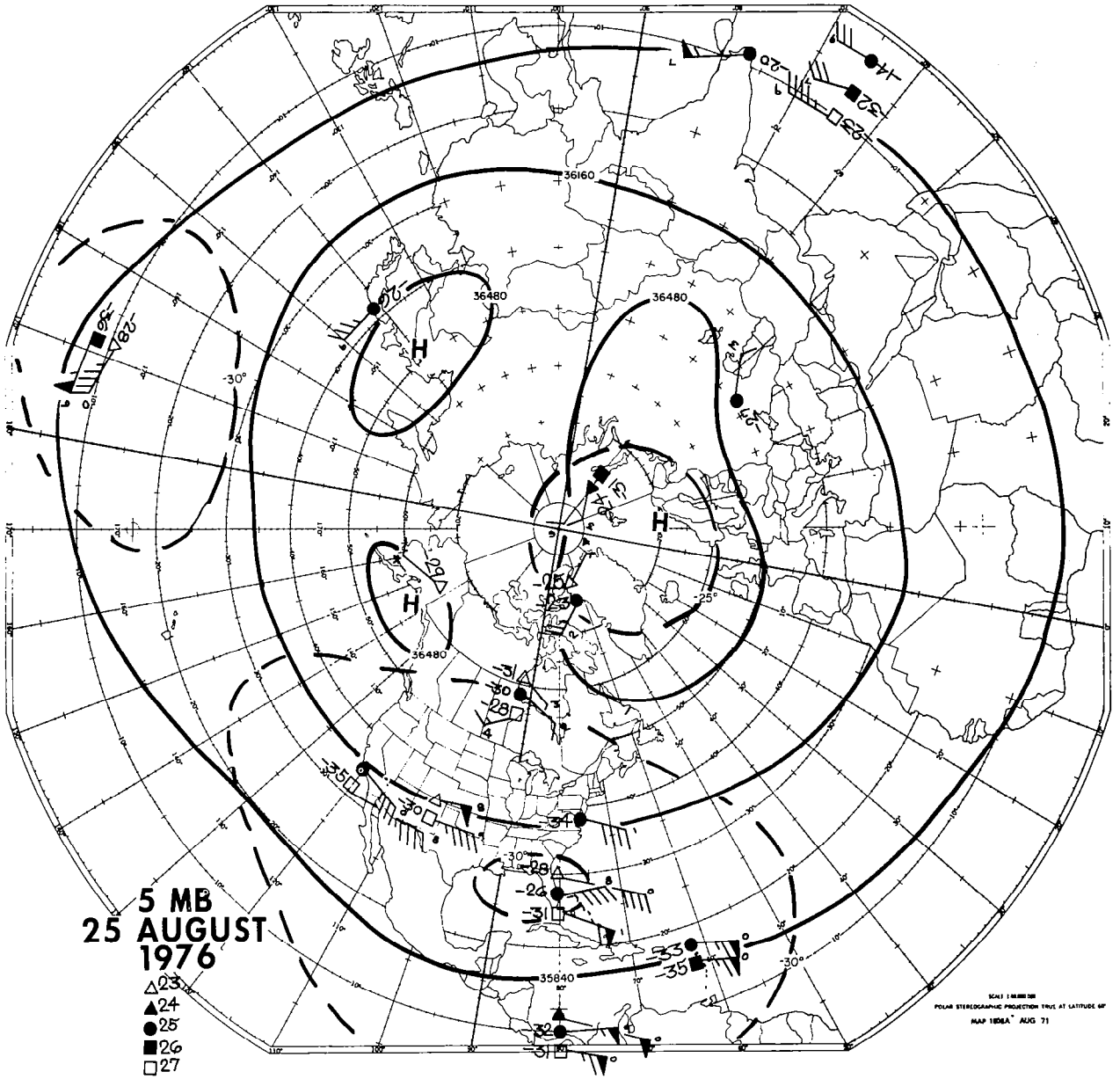
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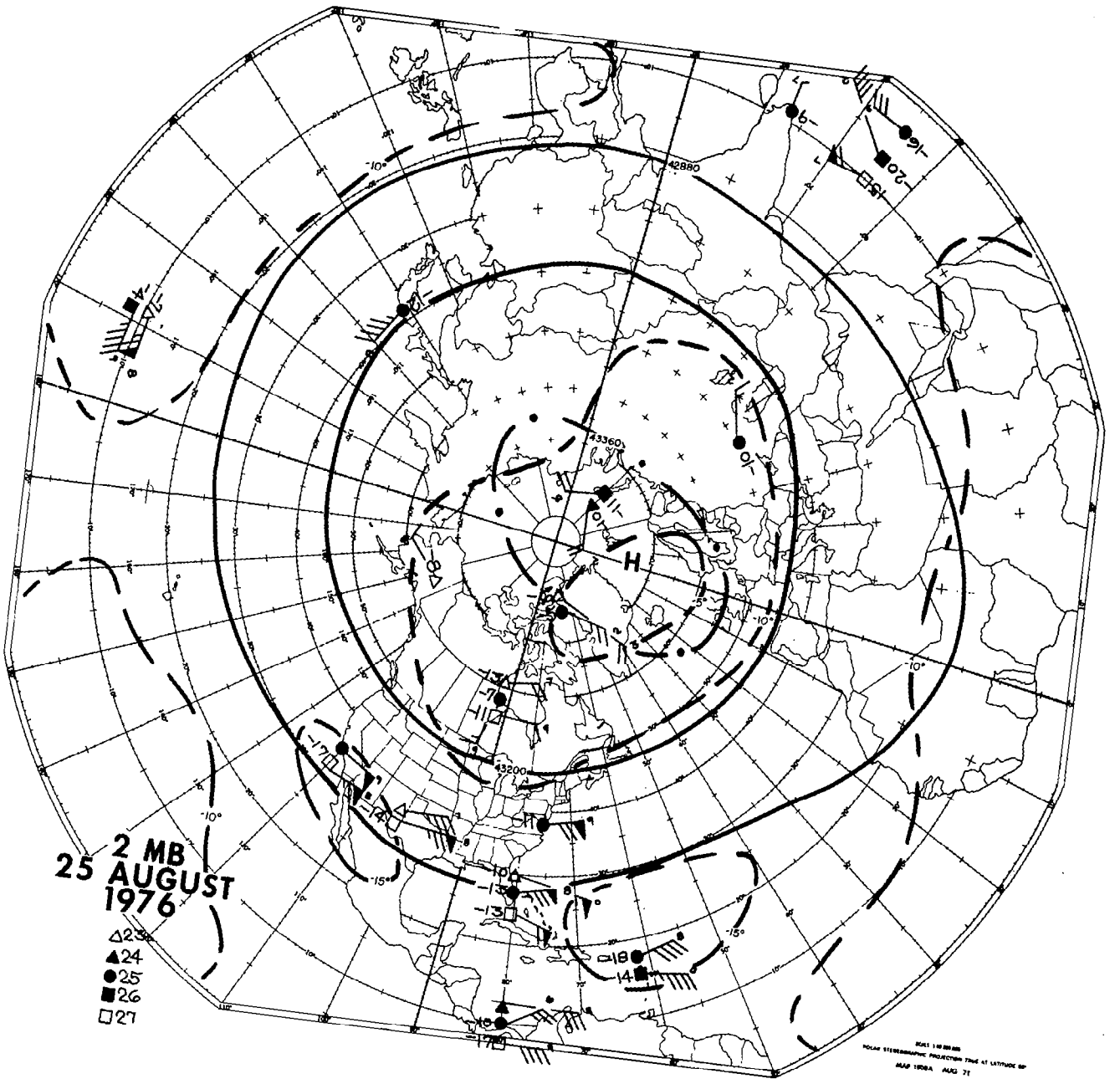
MAP 1858A* AUG 71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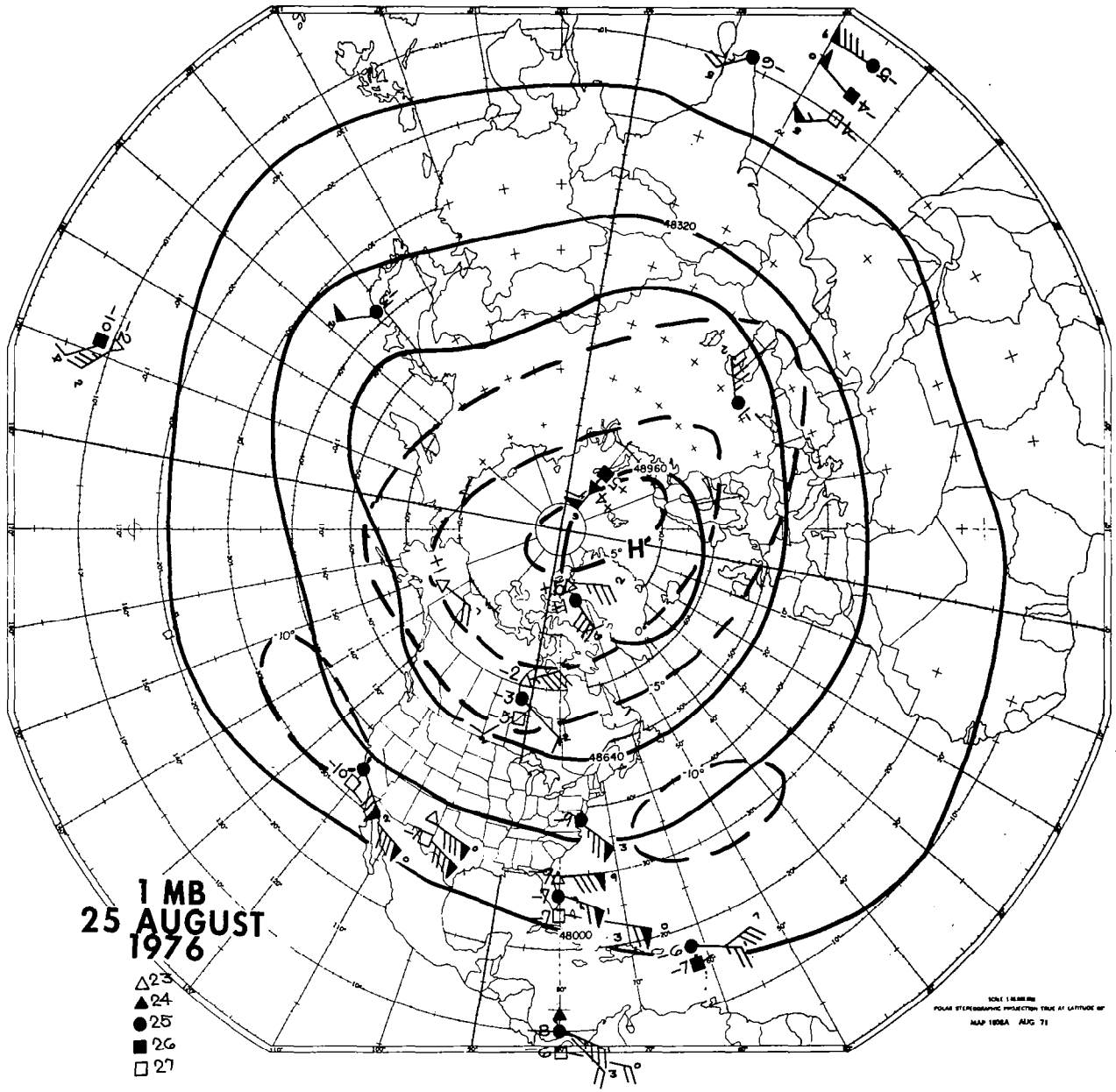
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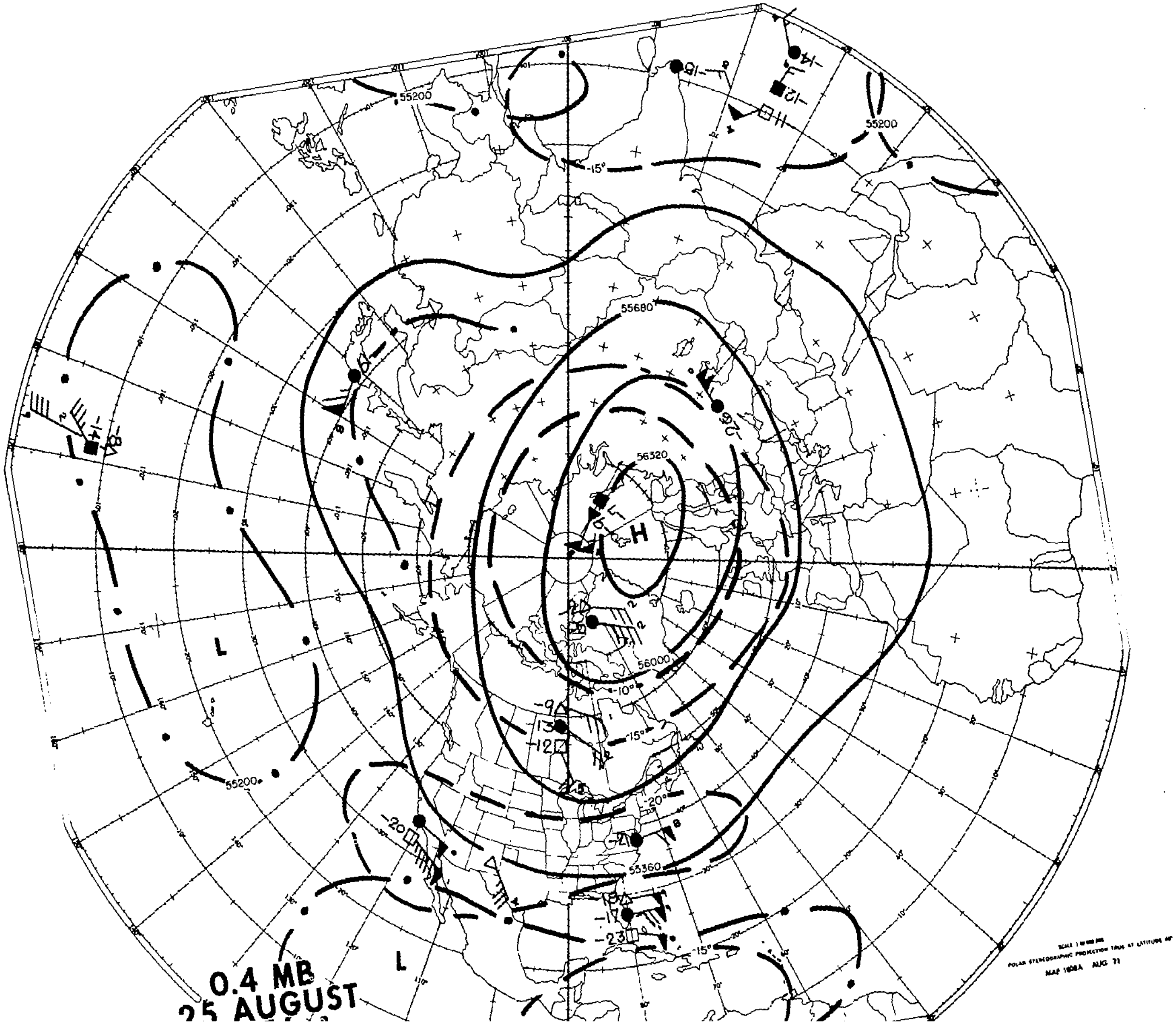
MAP 1606A AUG 71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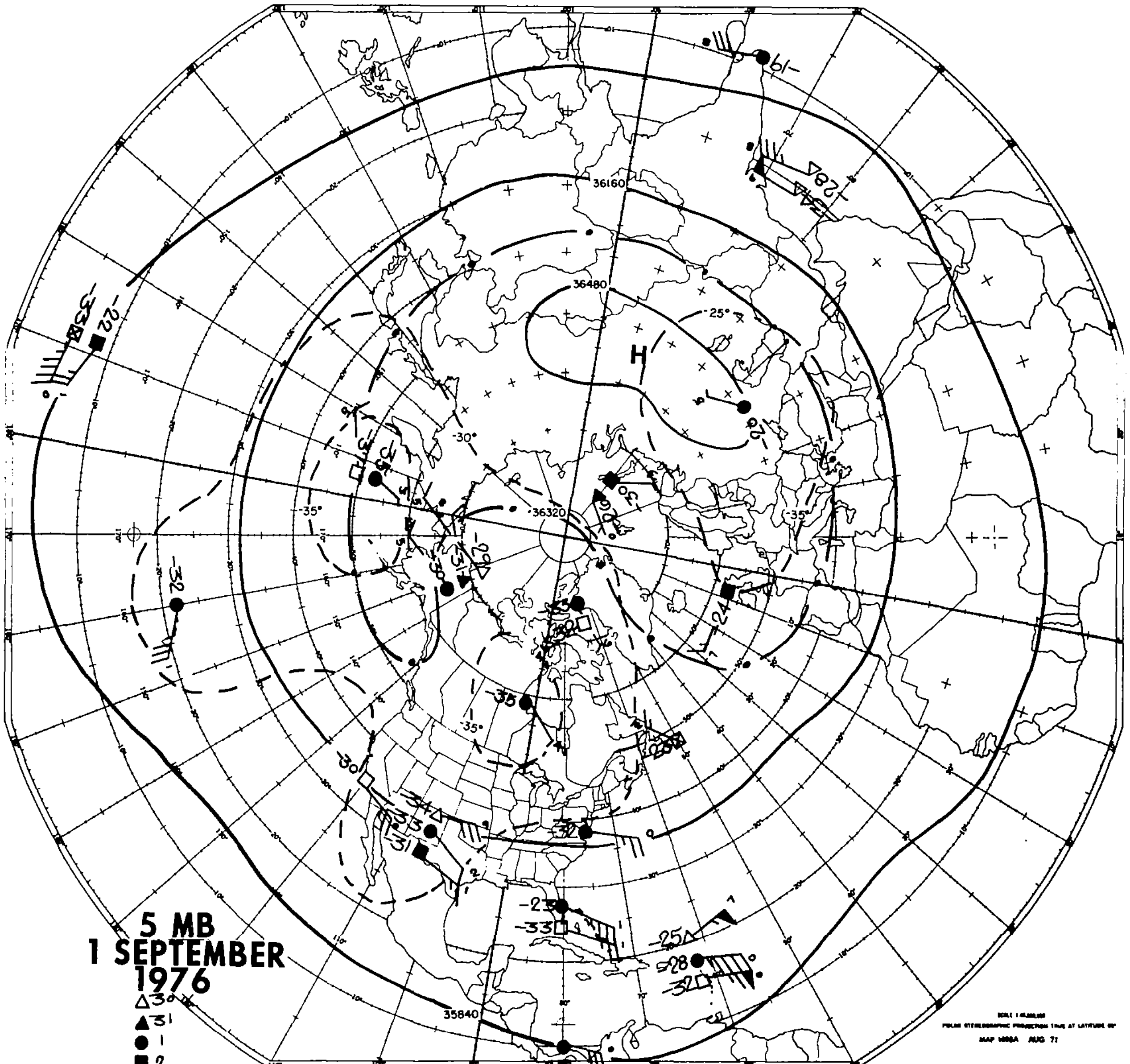

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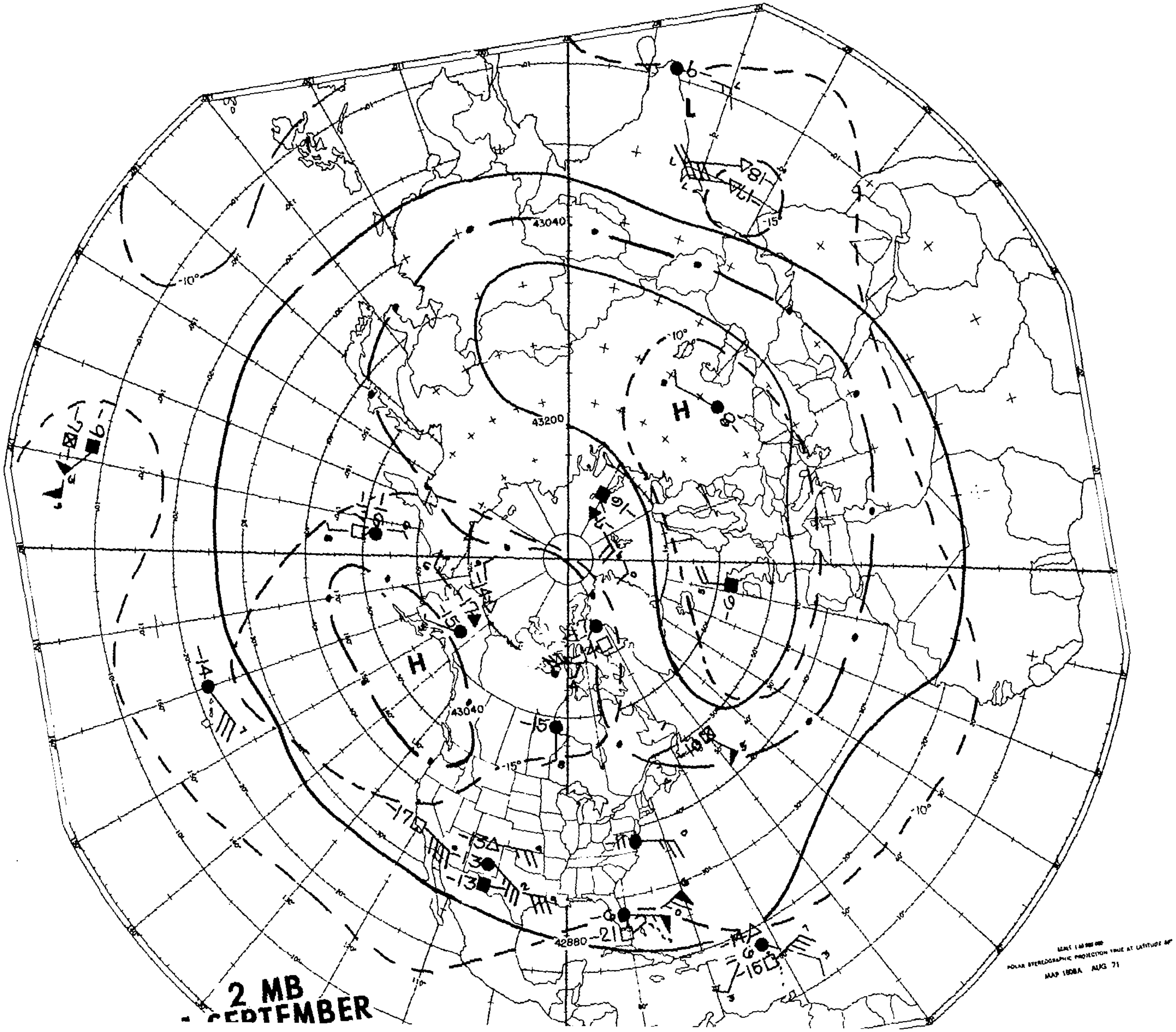
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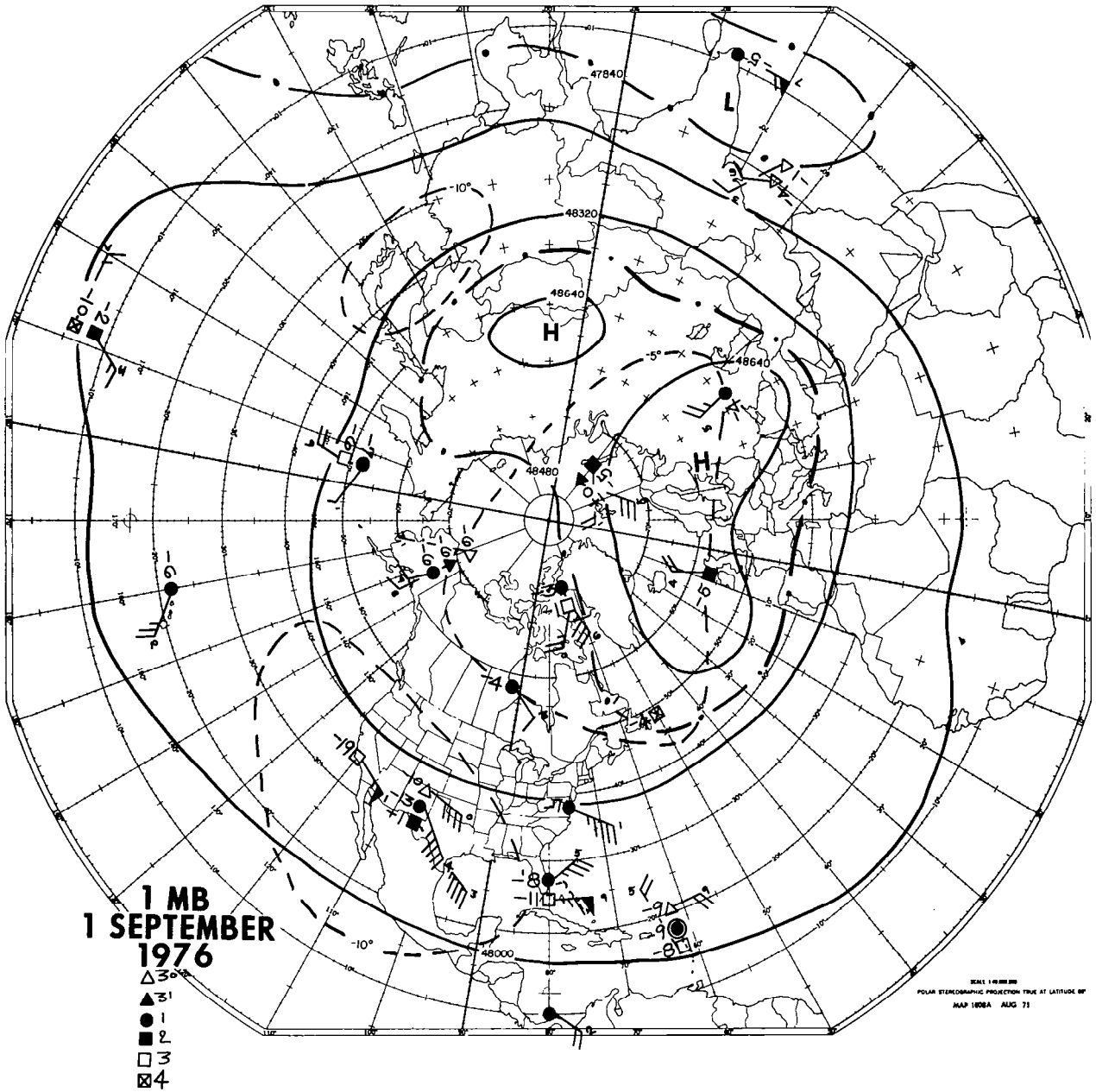
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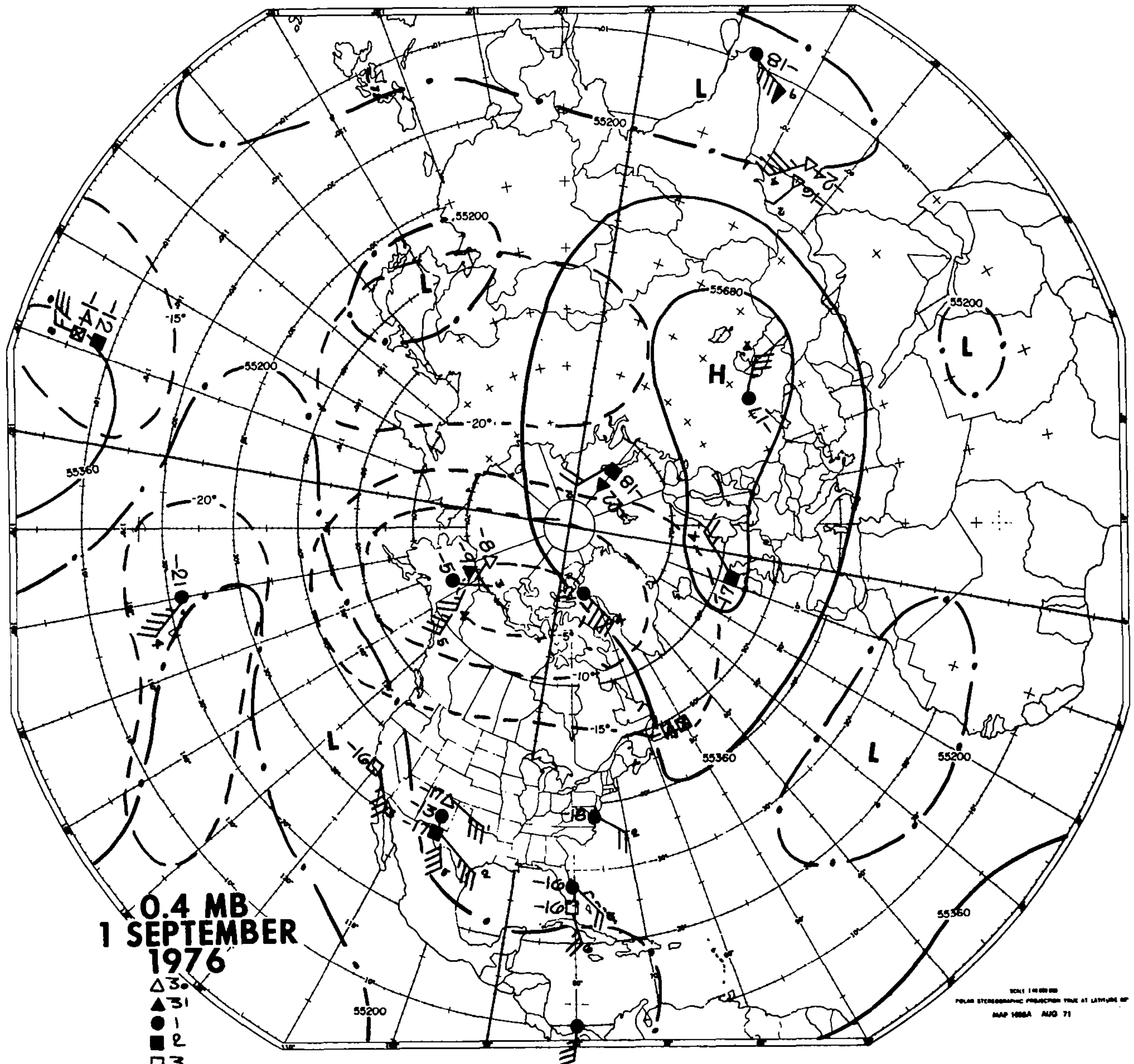
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1808A AUG 71



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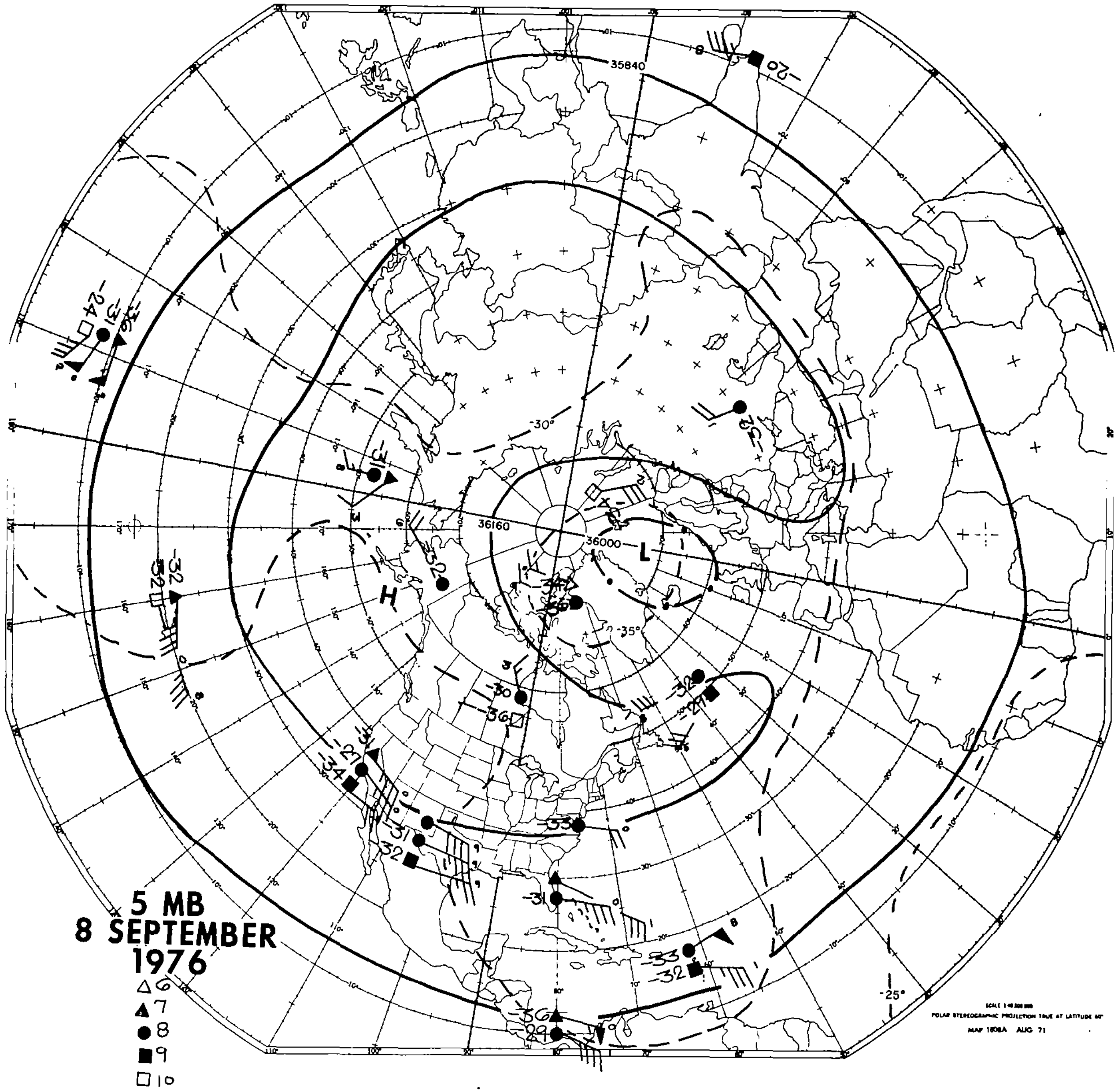
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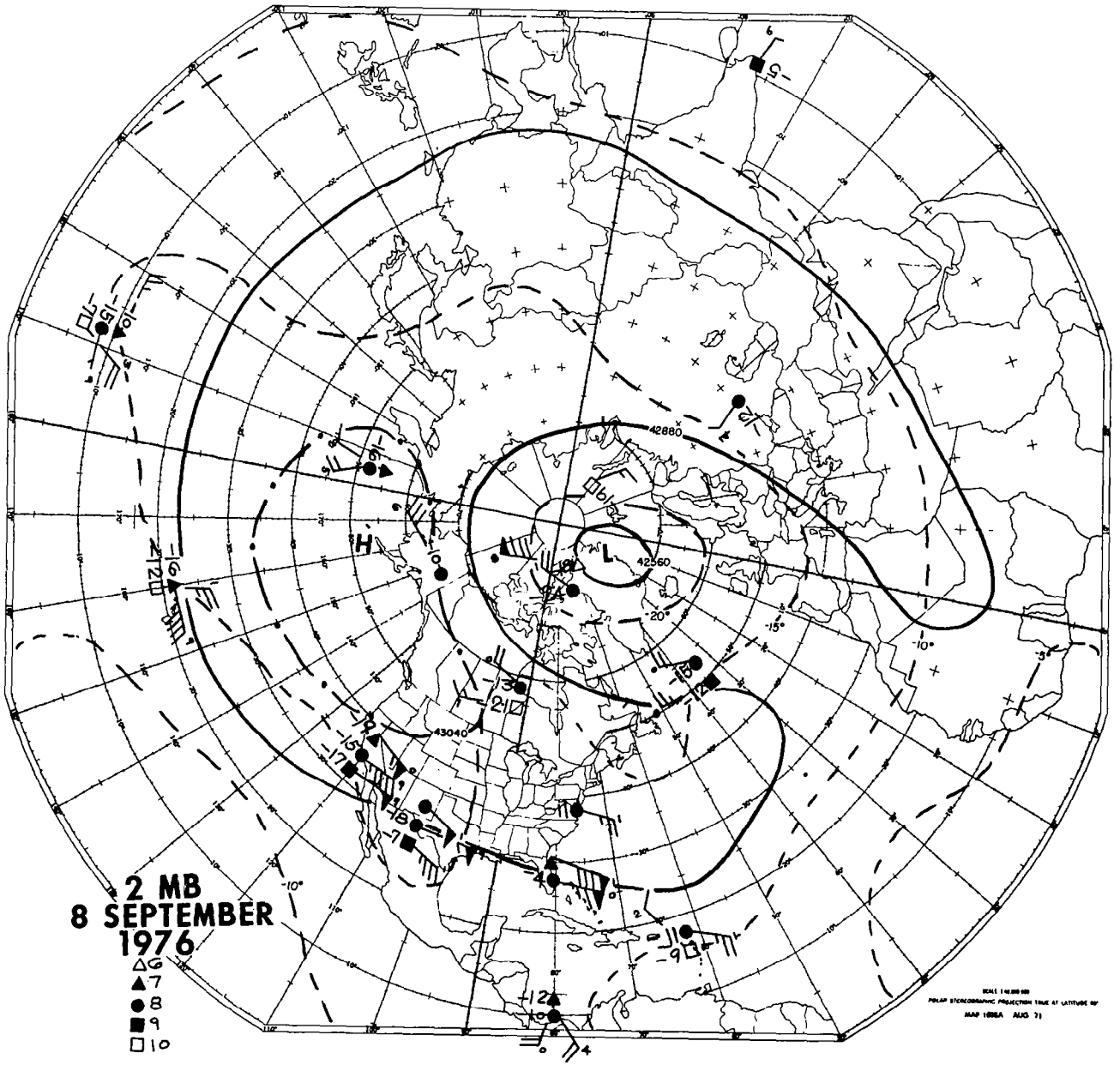
MAP 1608A AUG 71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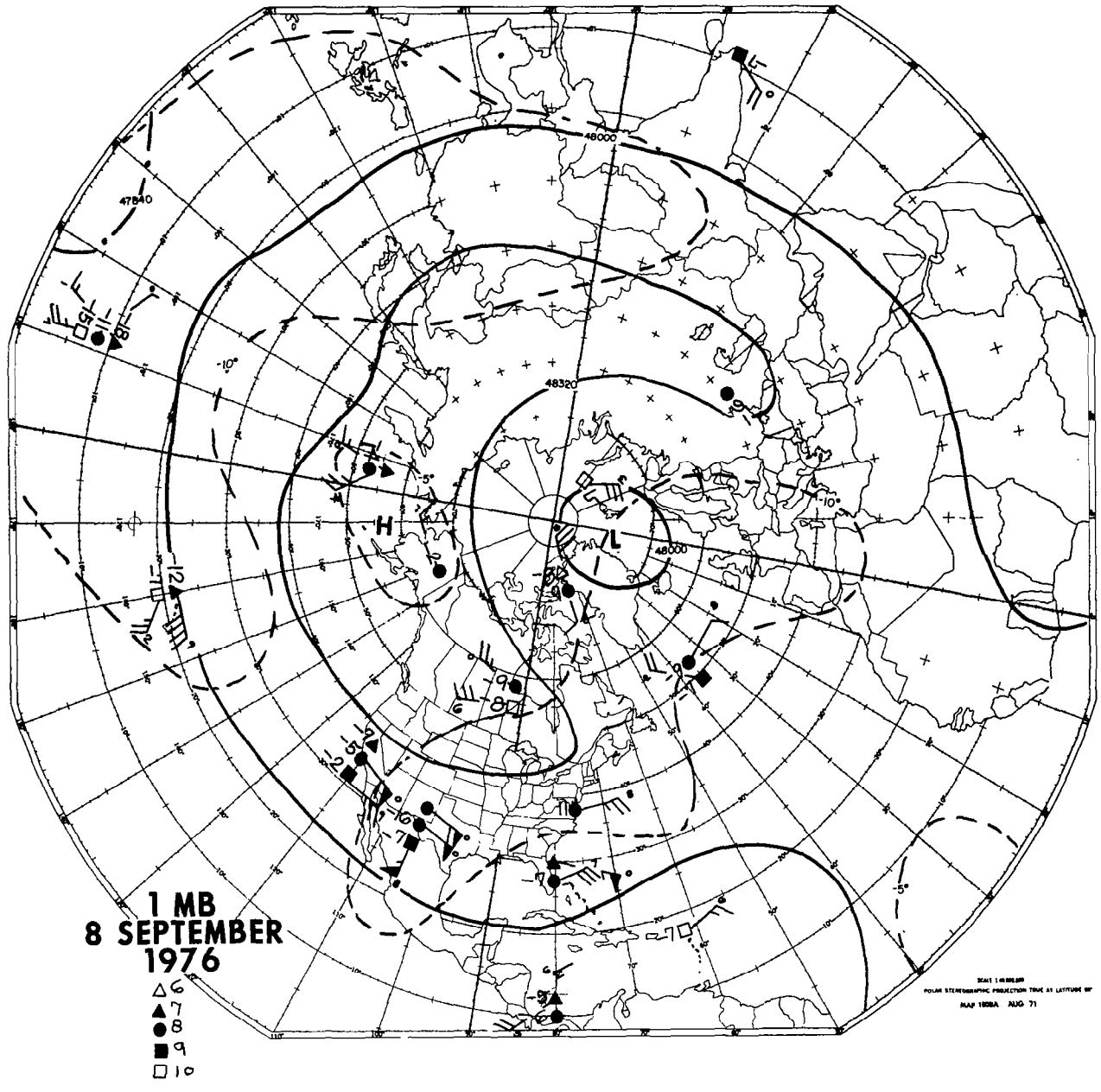
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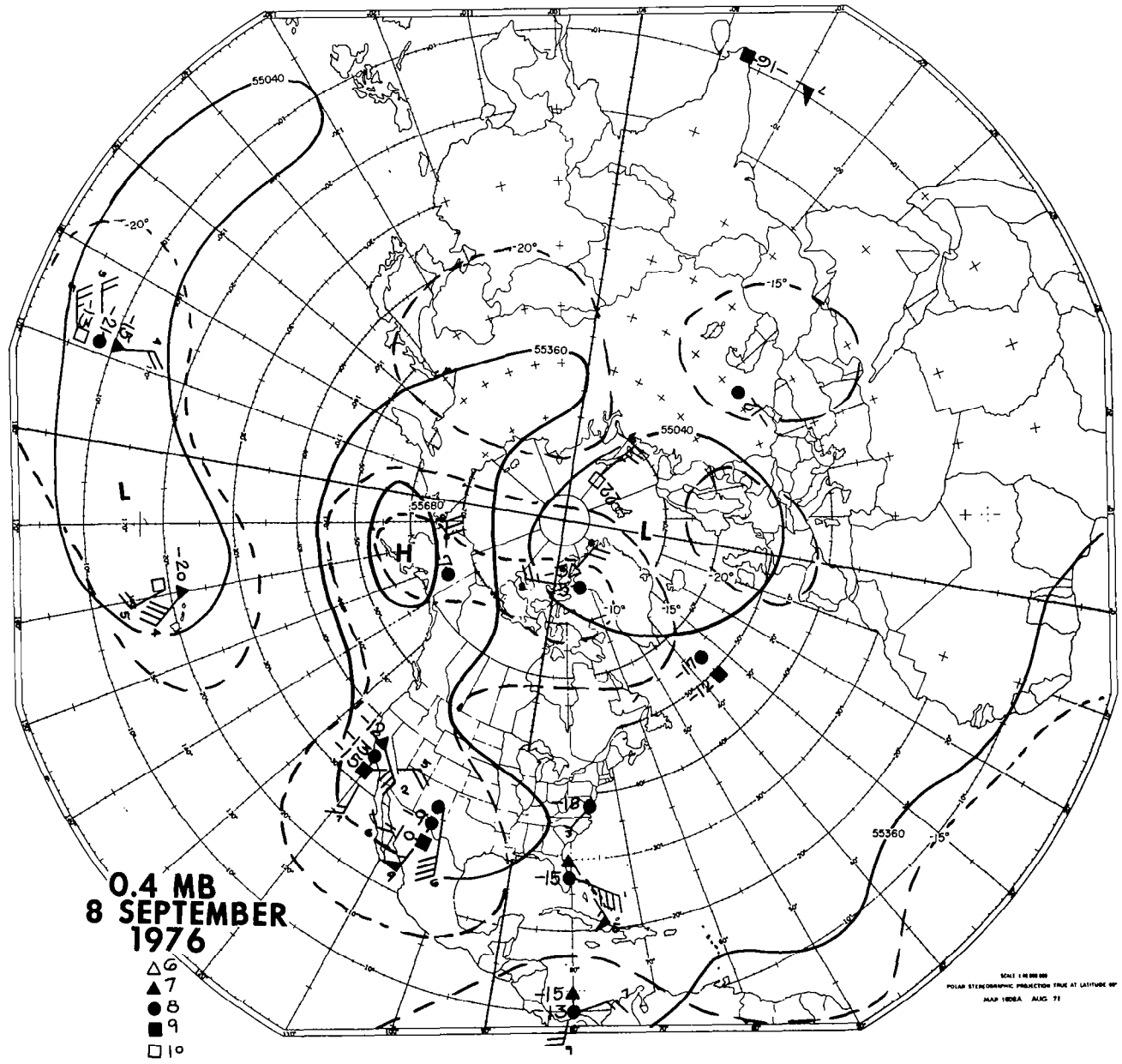
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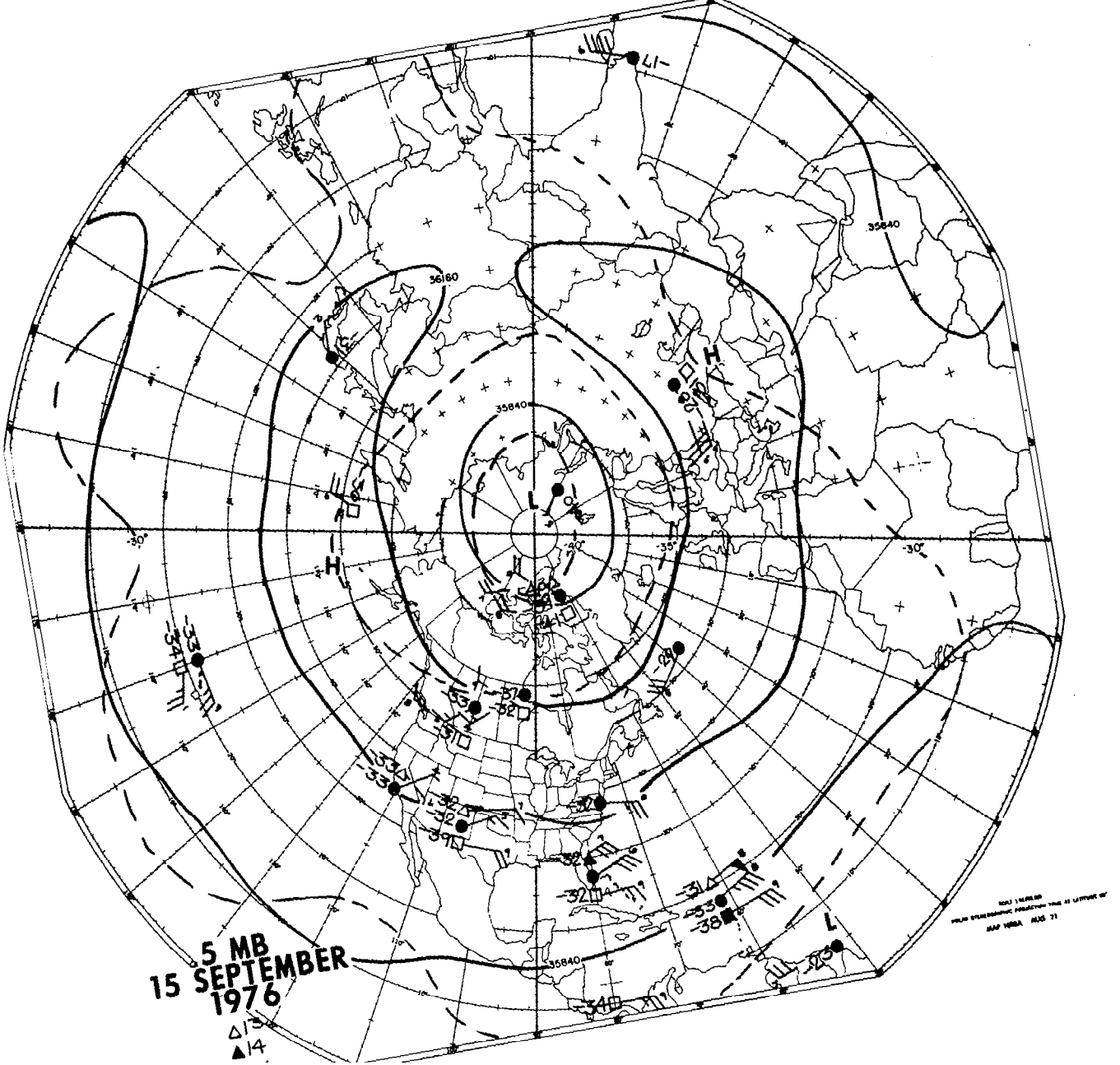
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1808A AUG 71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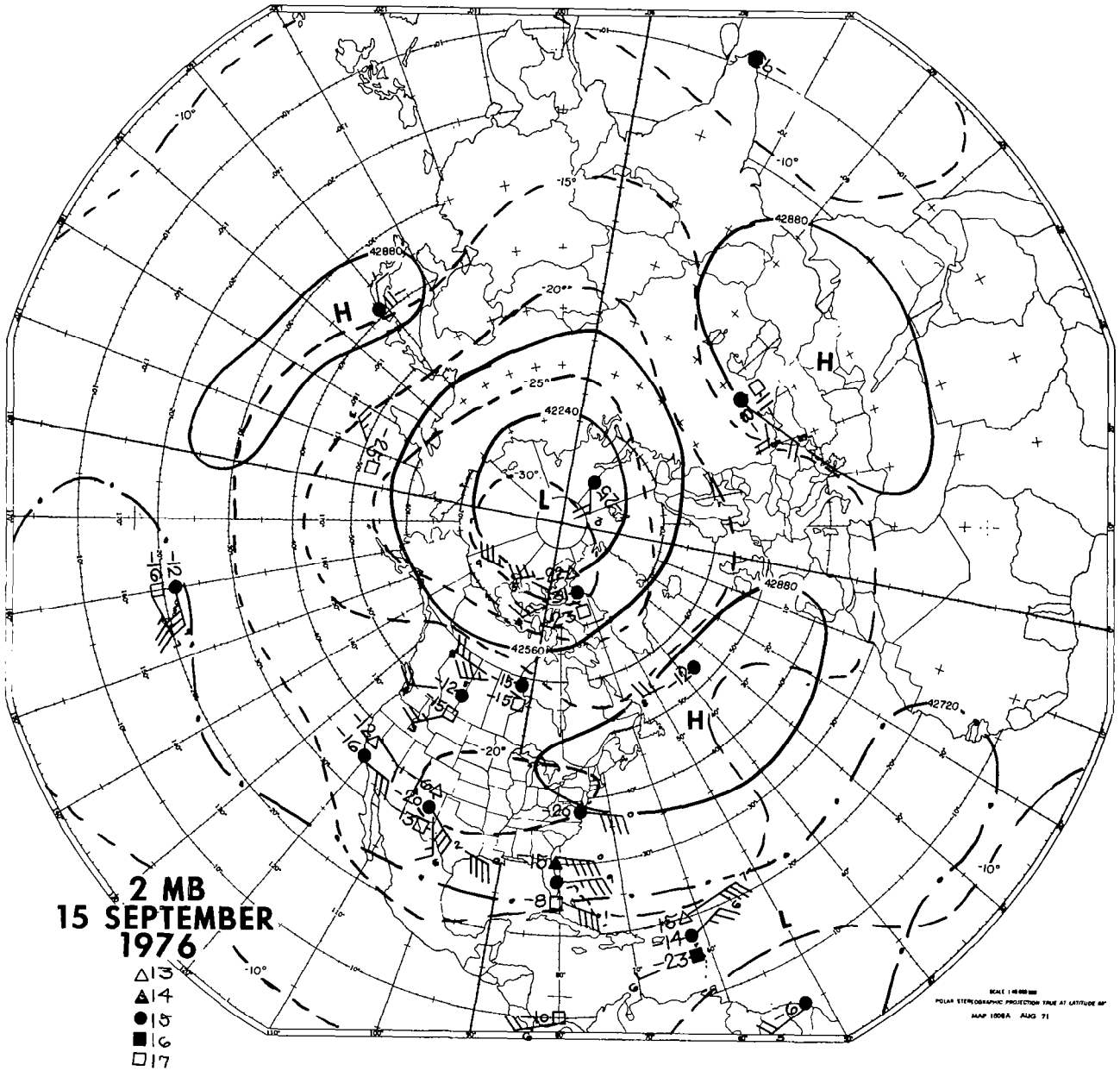
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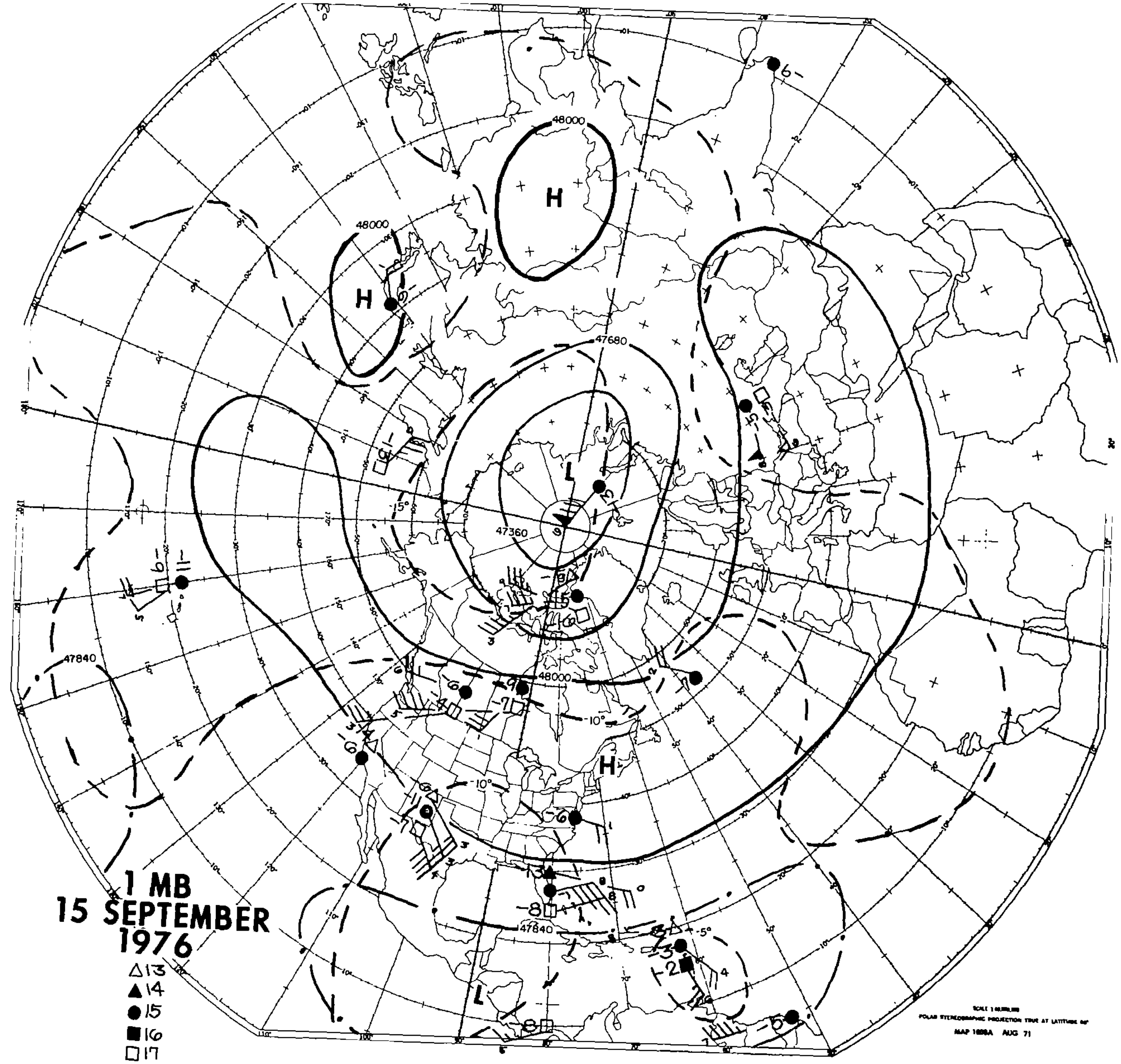

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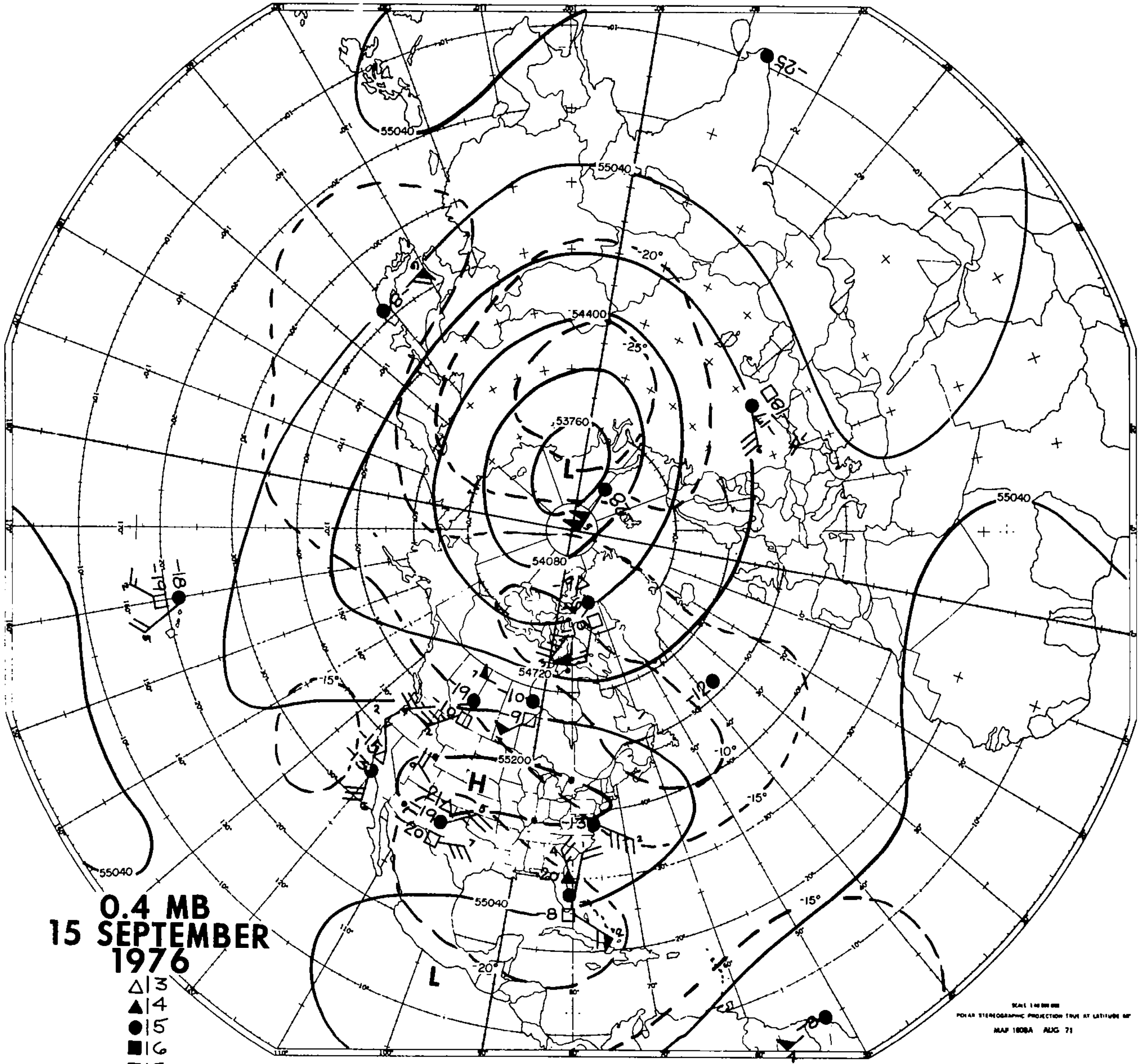

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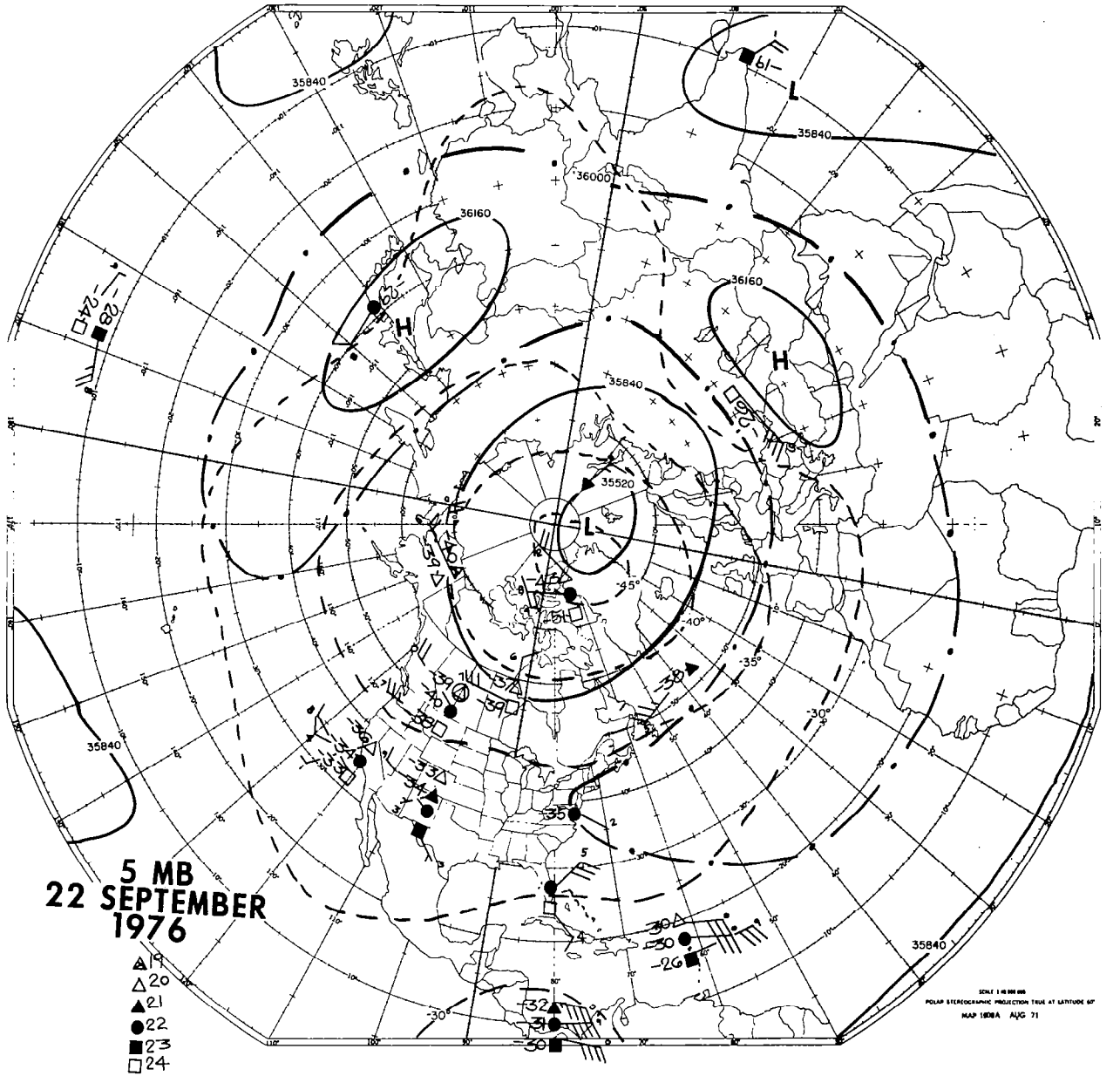
■|6
□|7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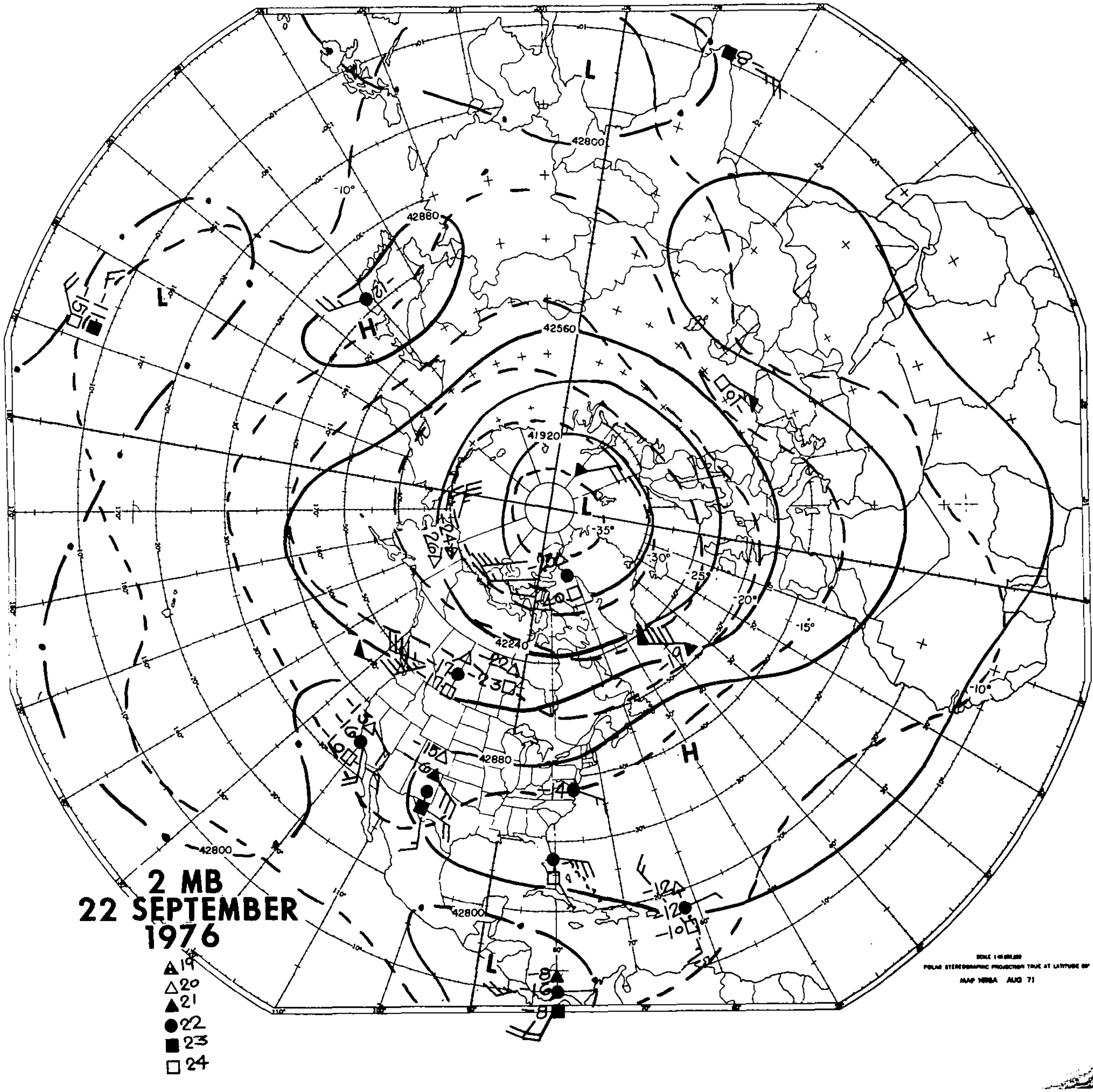
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1608A AUG 71



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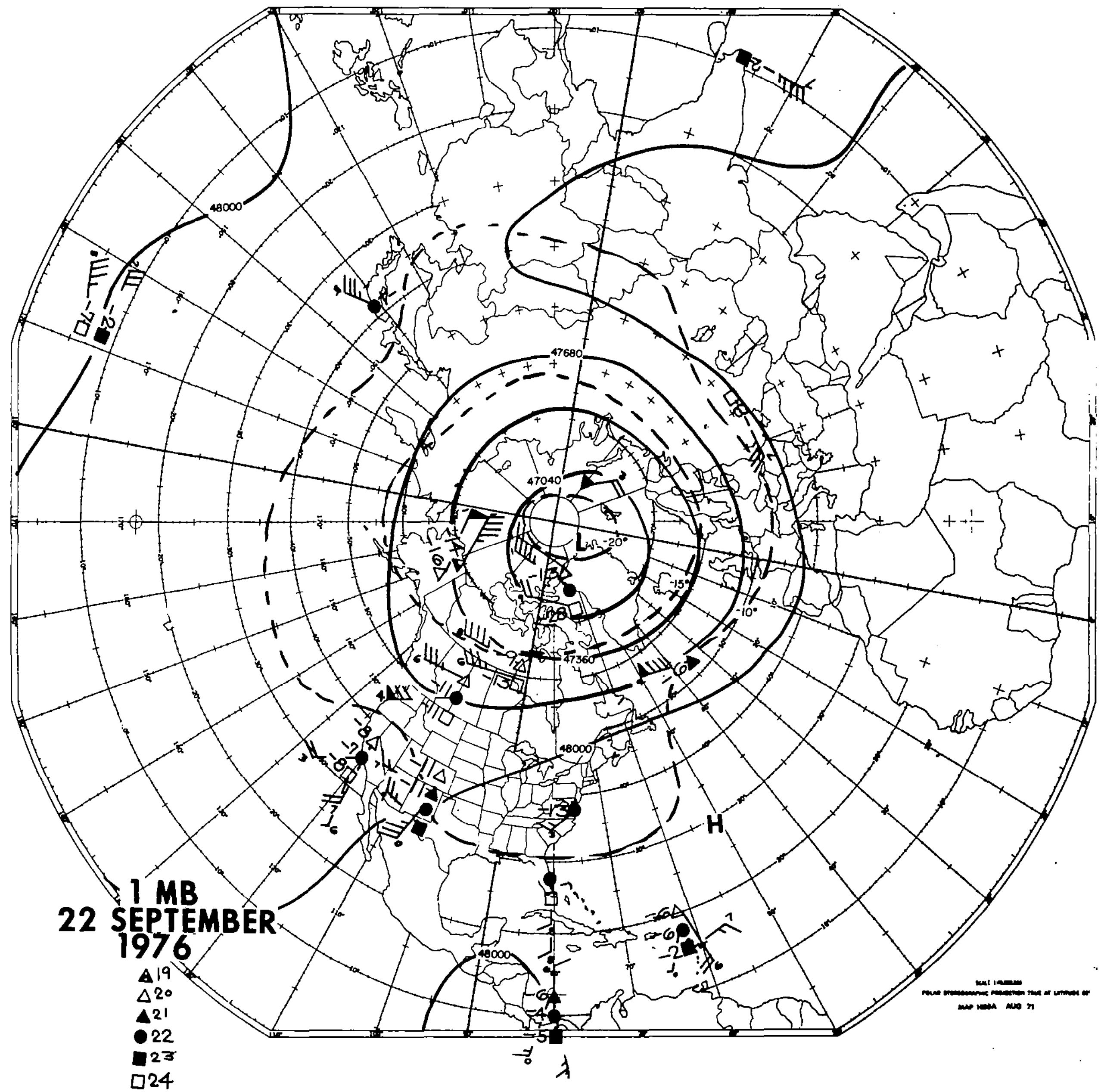

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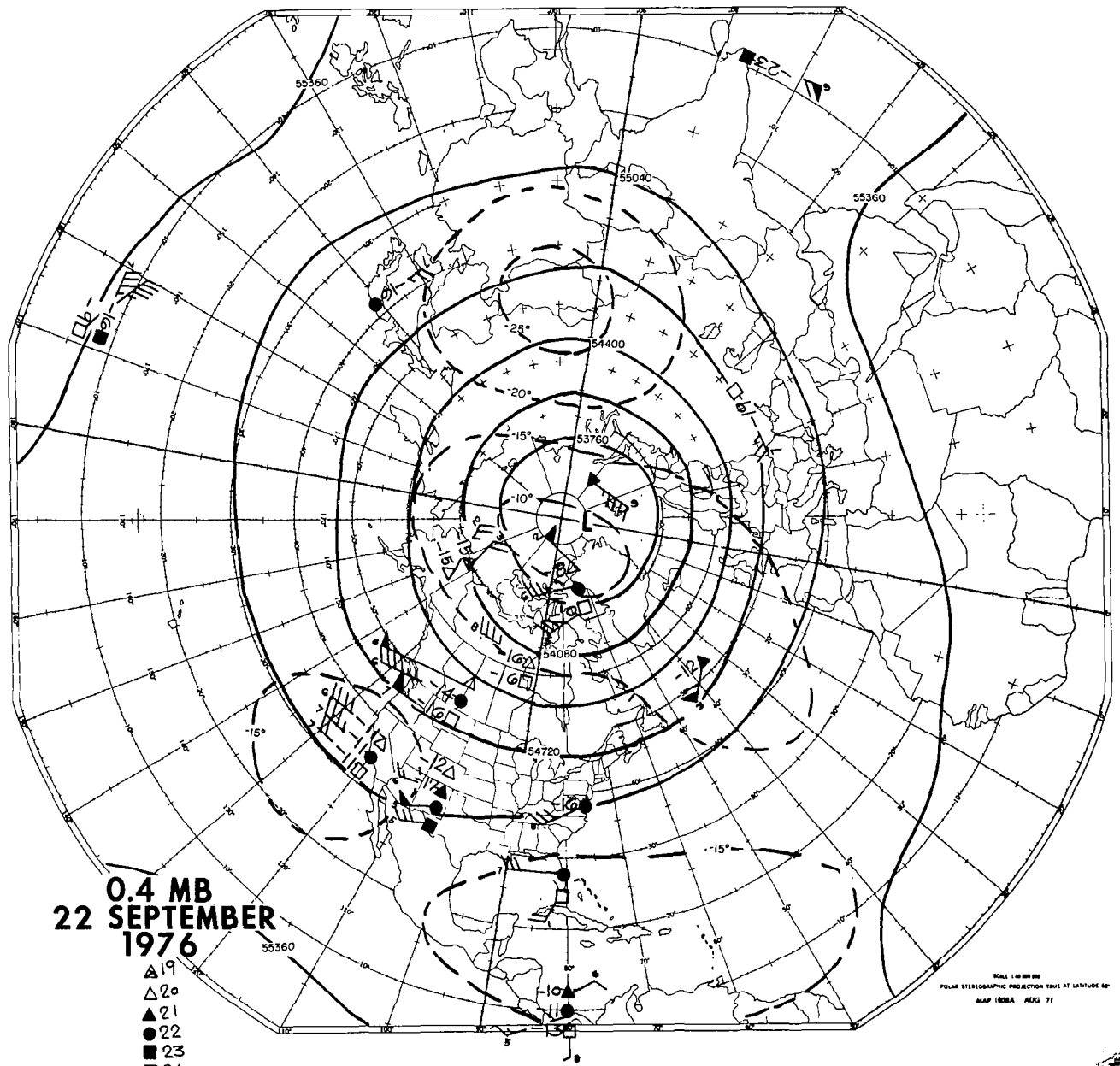
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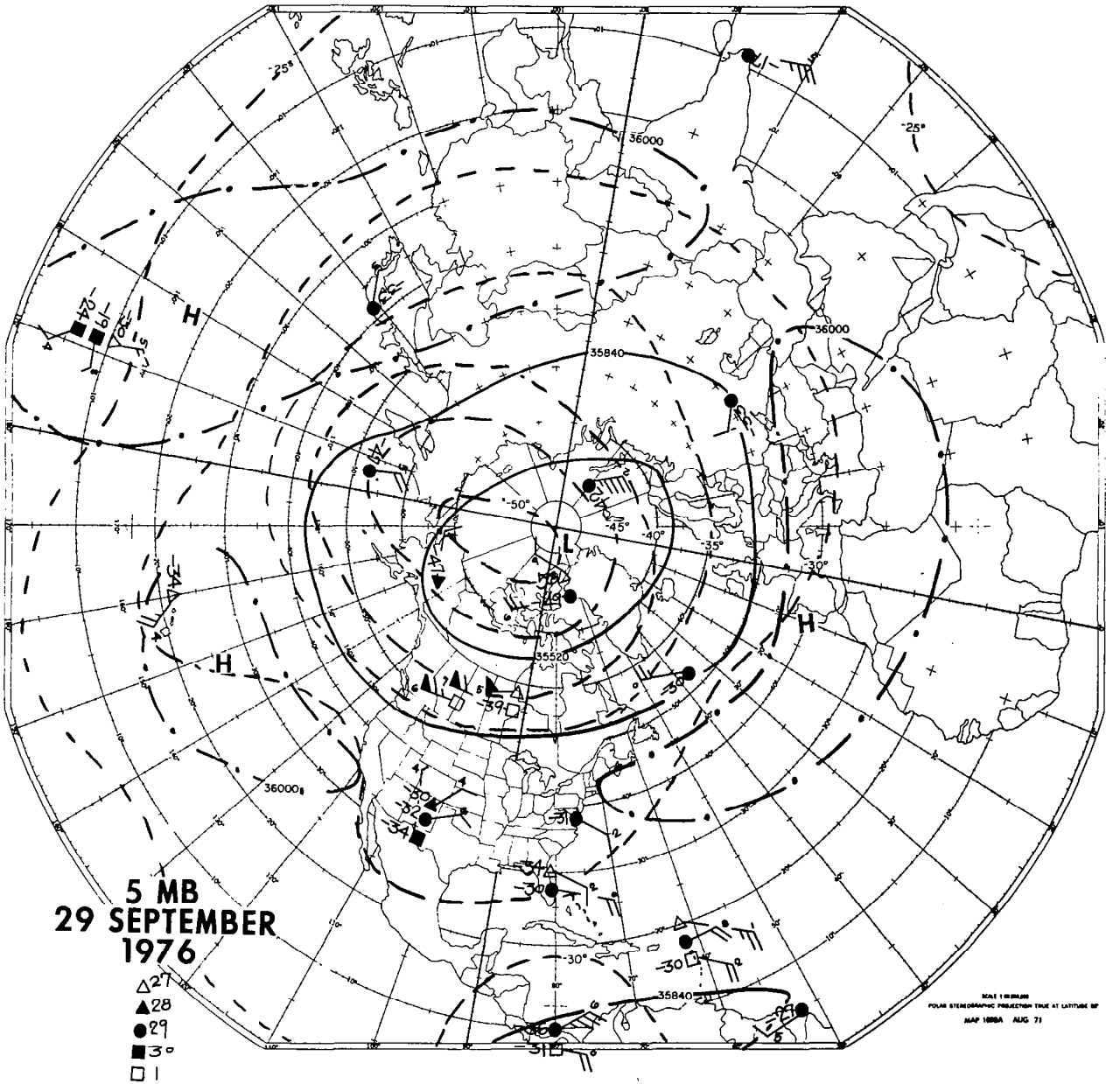
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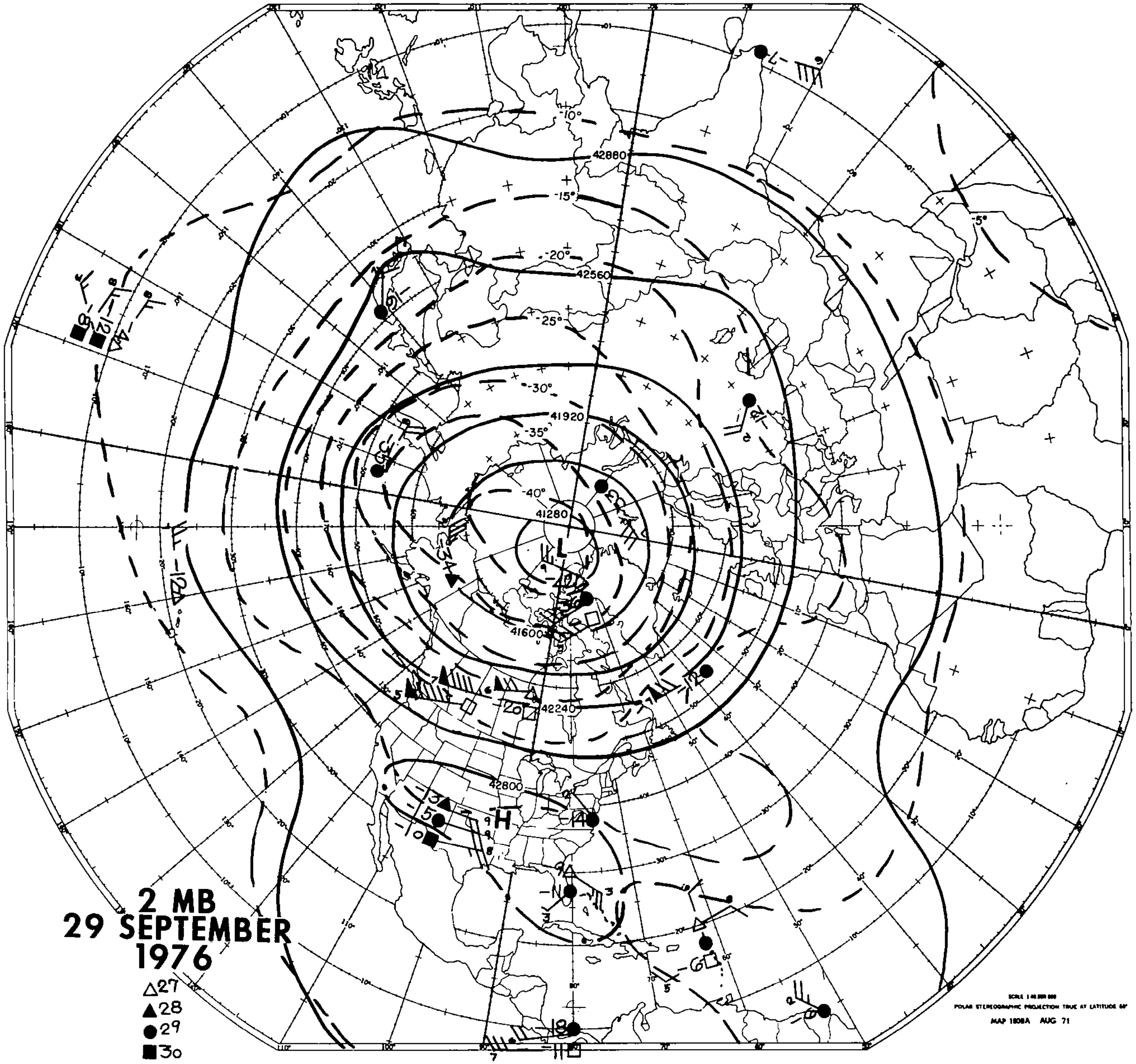
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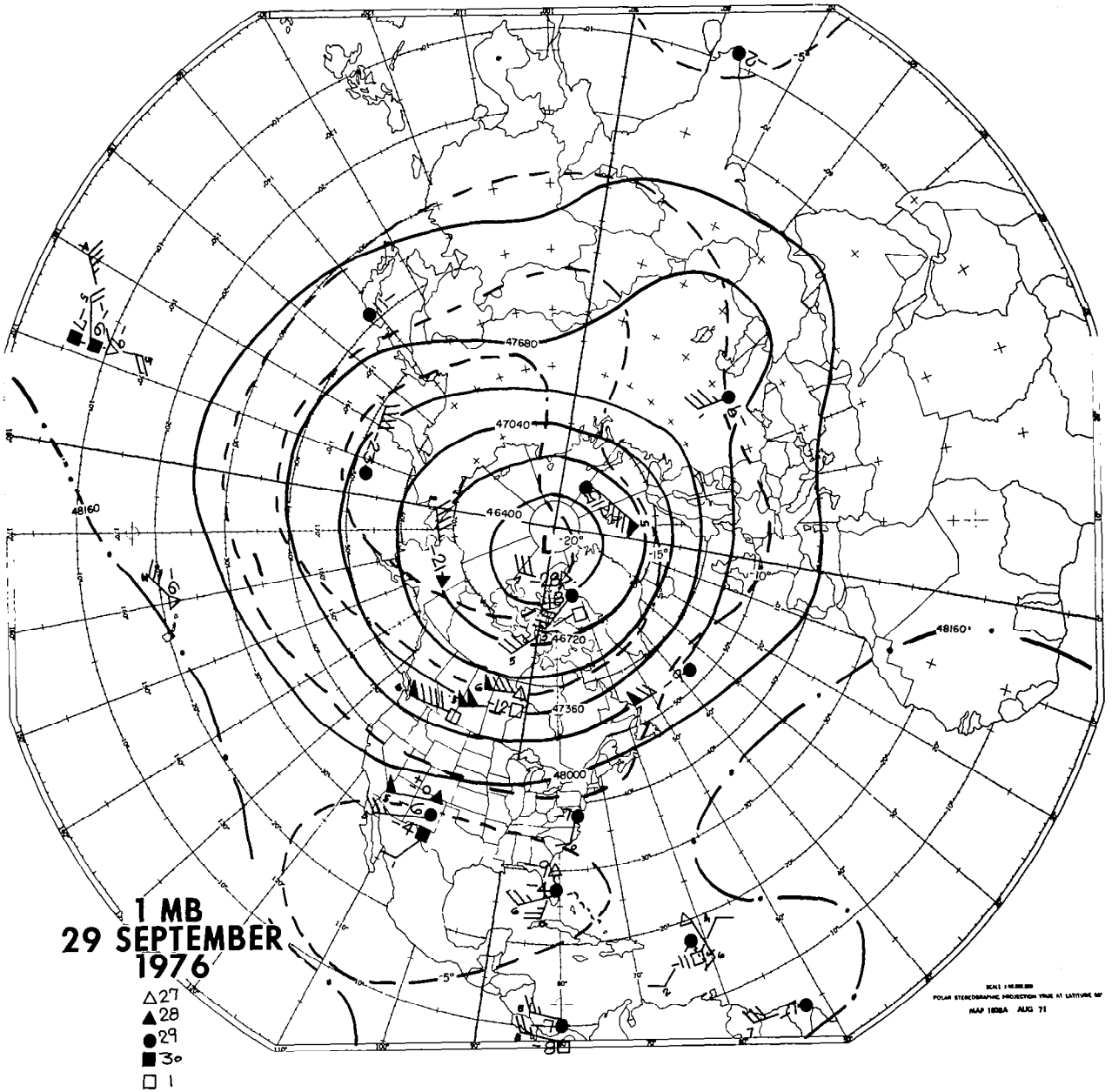
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1808A AUG 71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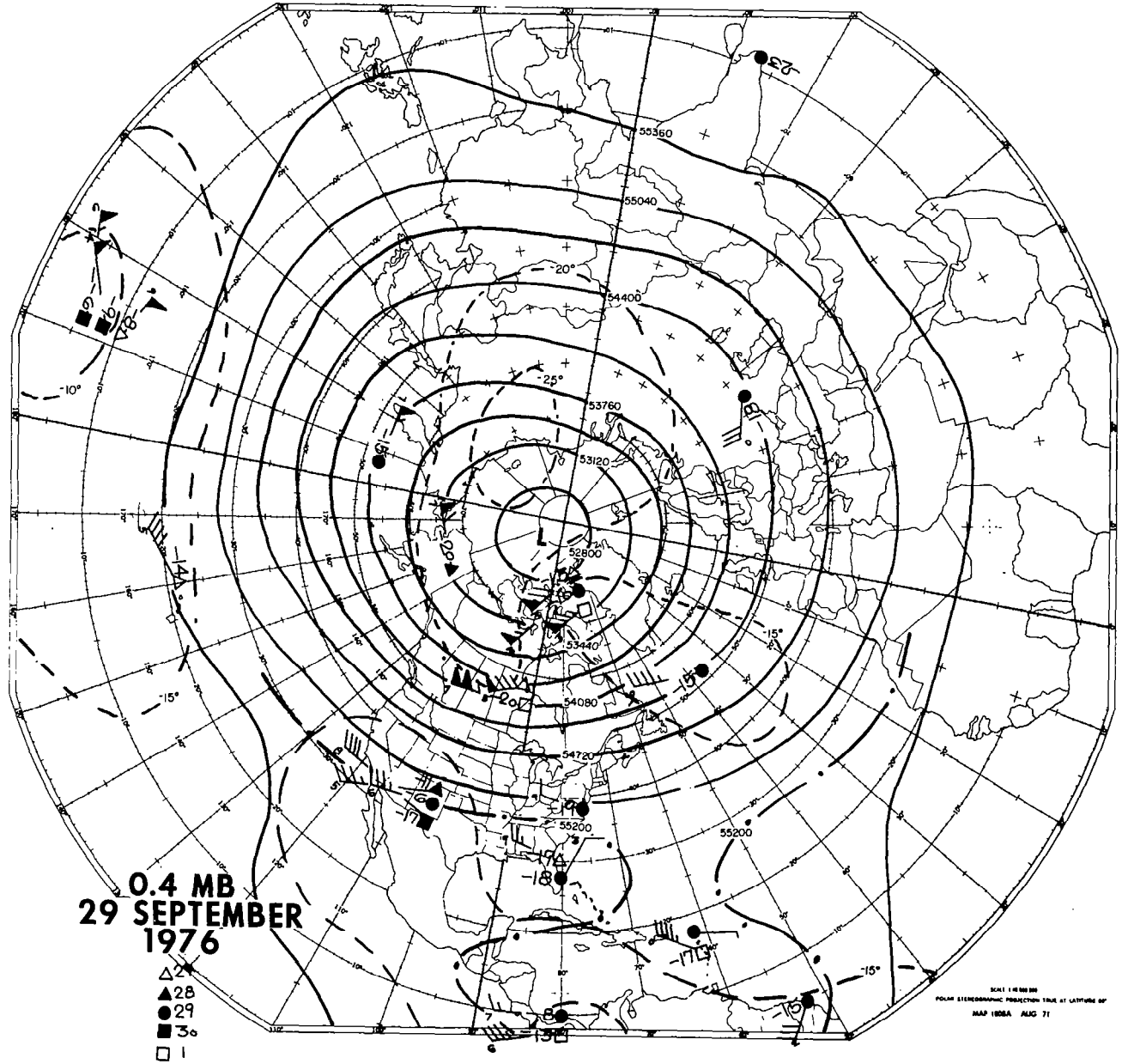
MAP 1808A AUG 71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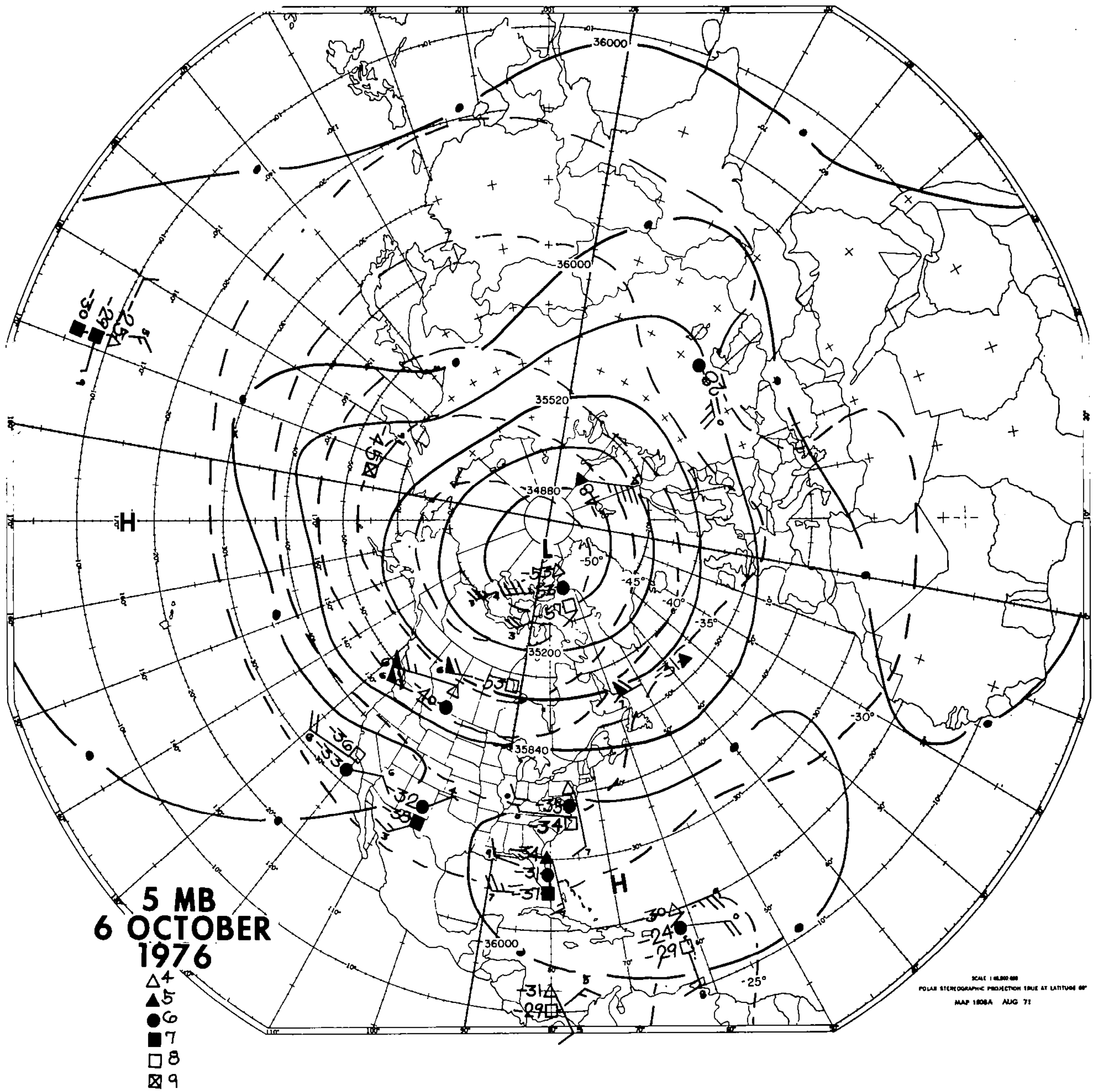
MAP 1008A AUG 71



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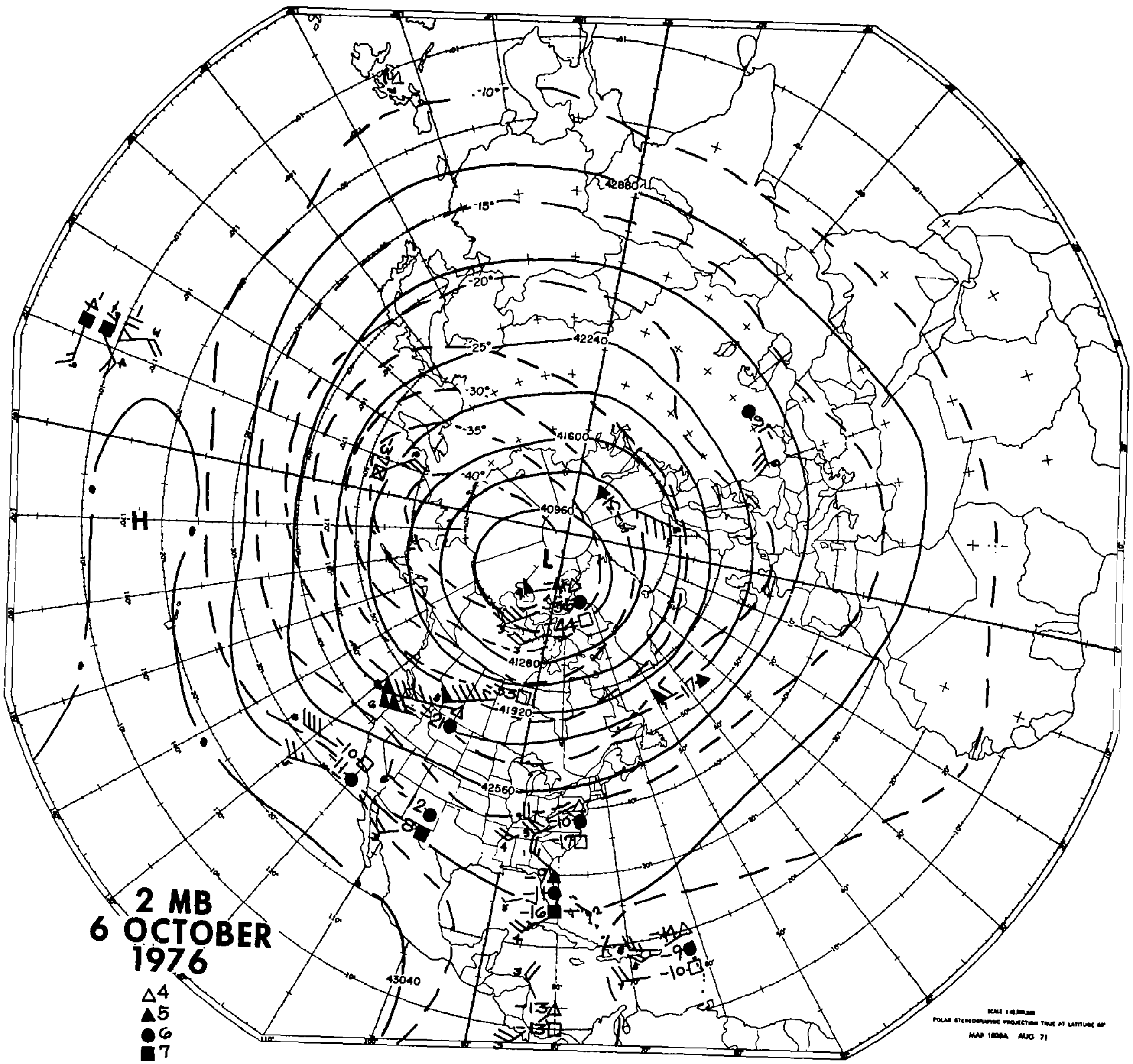
MAP 1806A AUG 71



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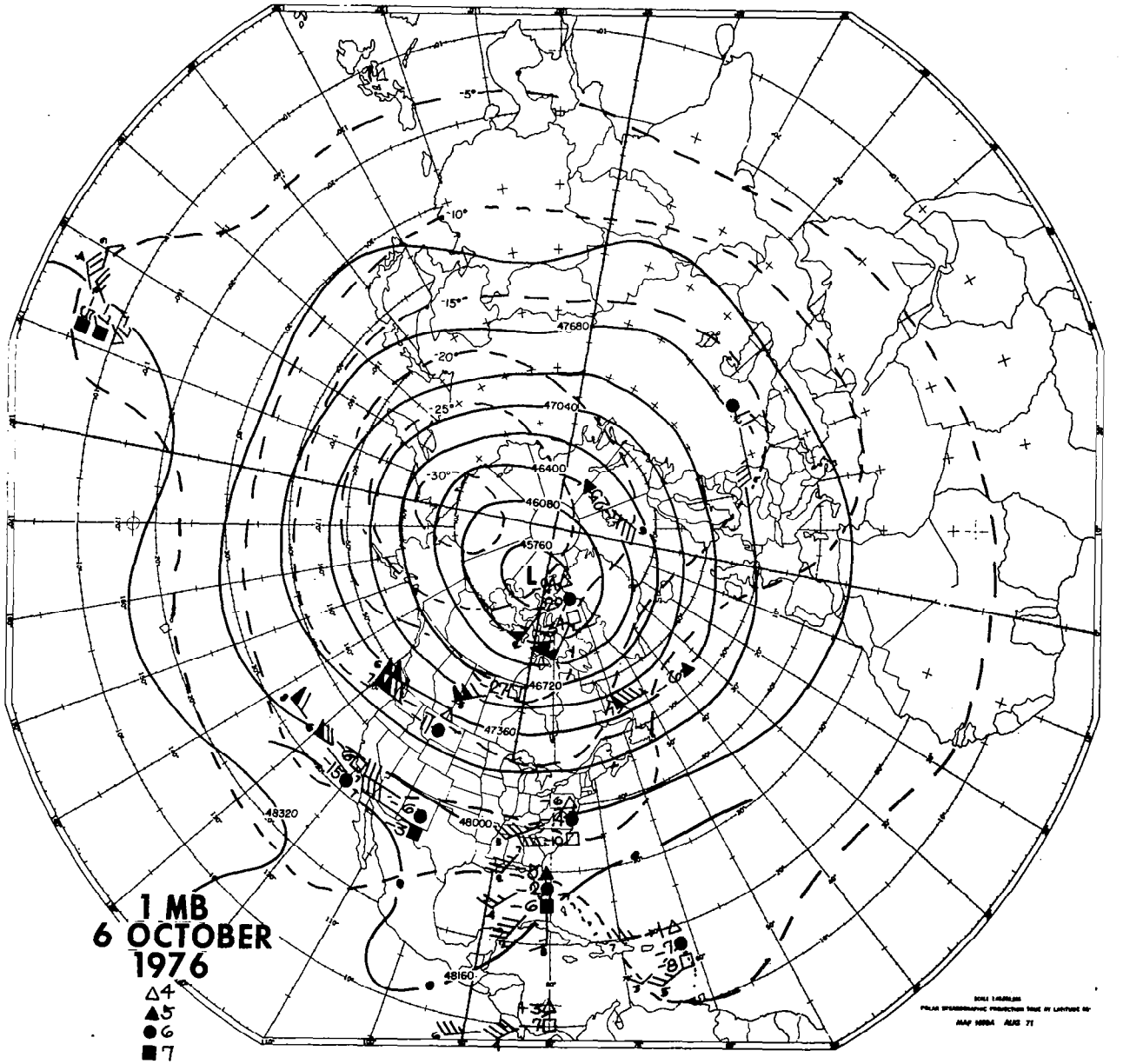
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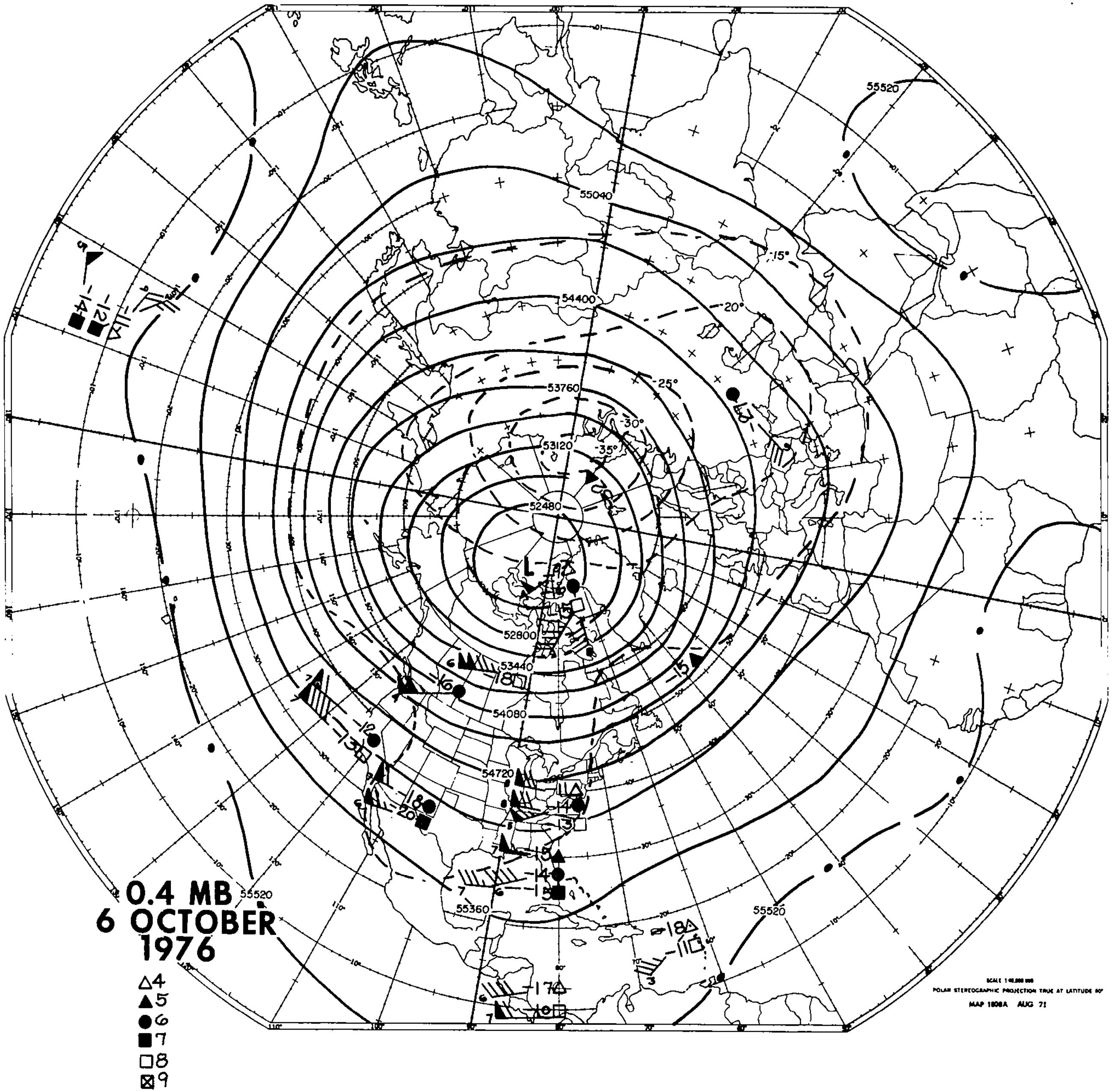
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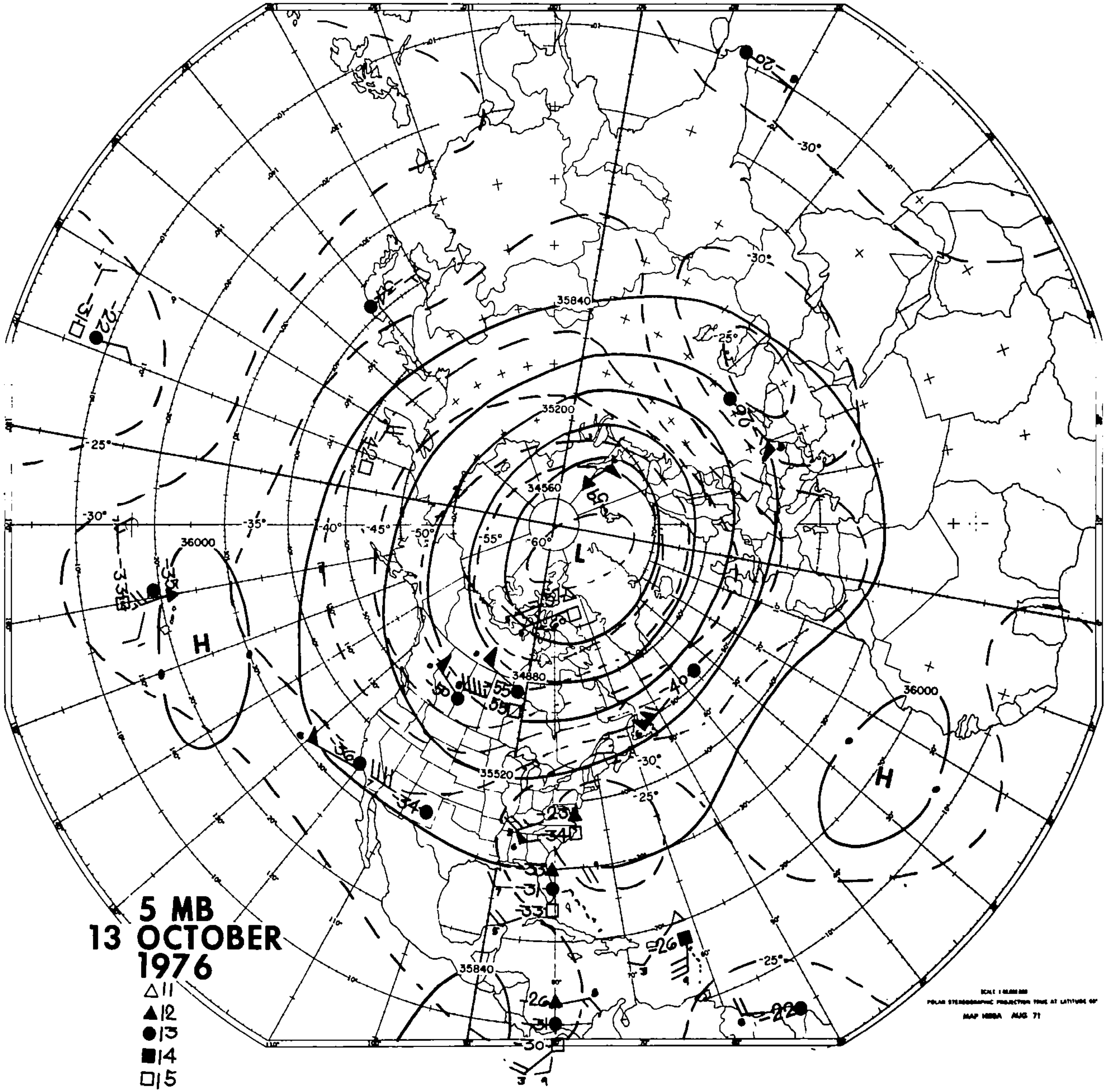
MAP 1808A AUG 71



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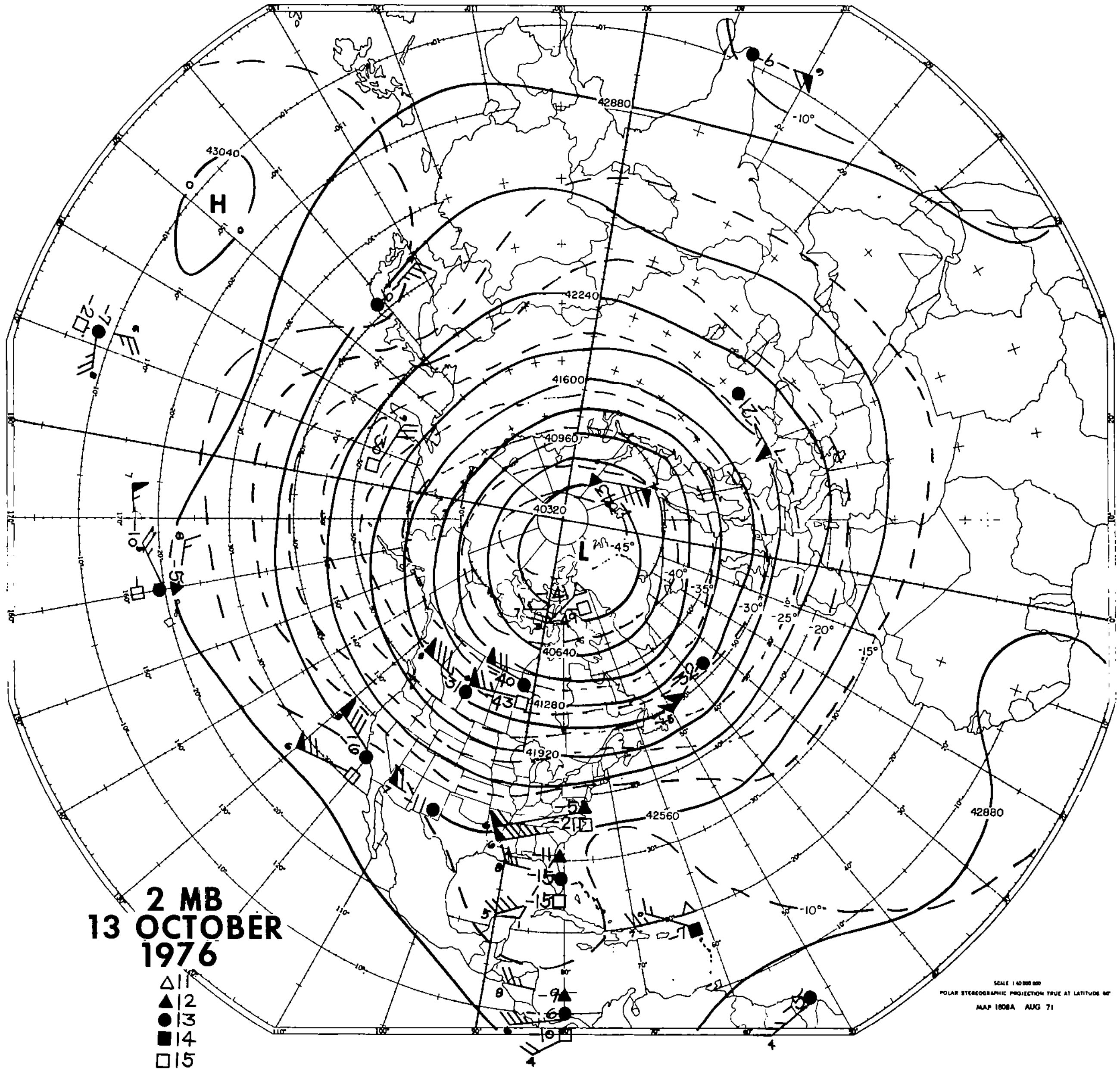

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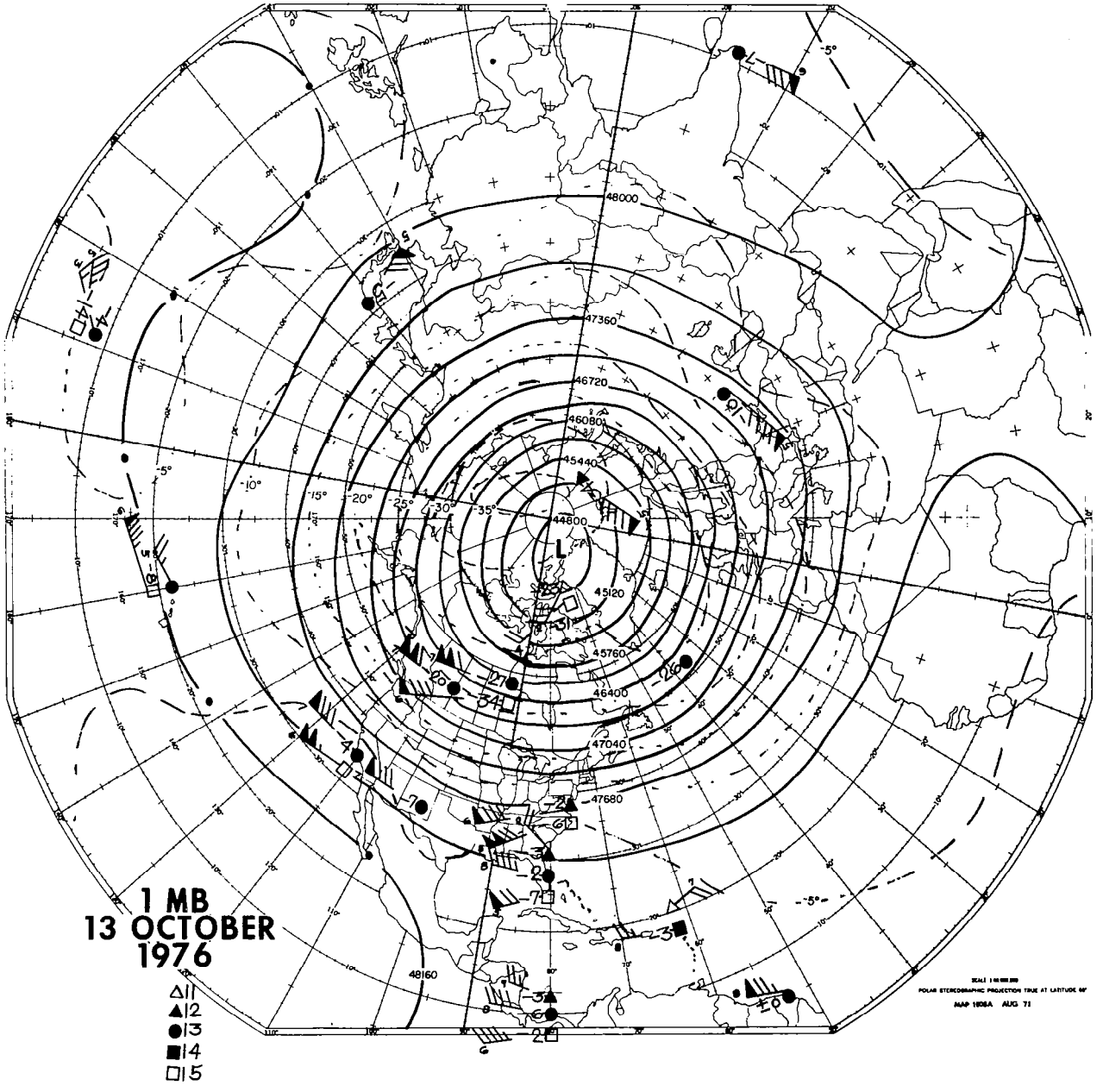
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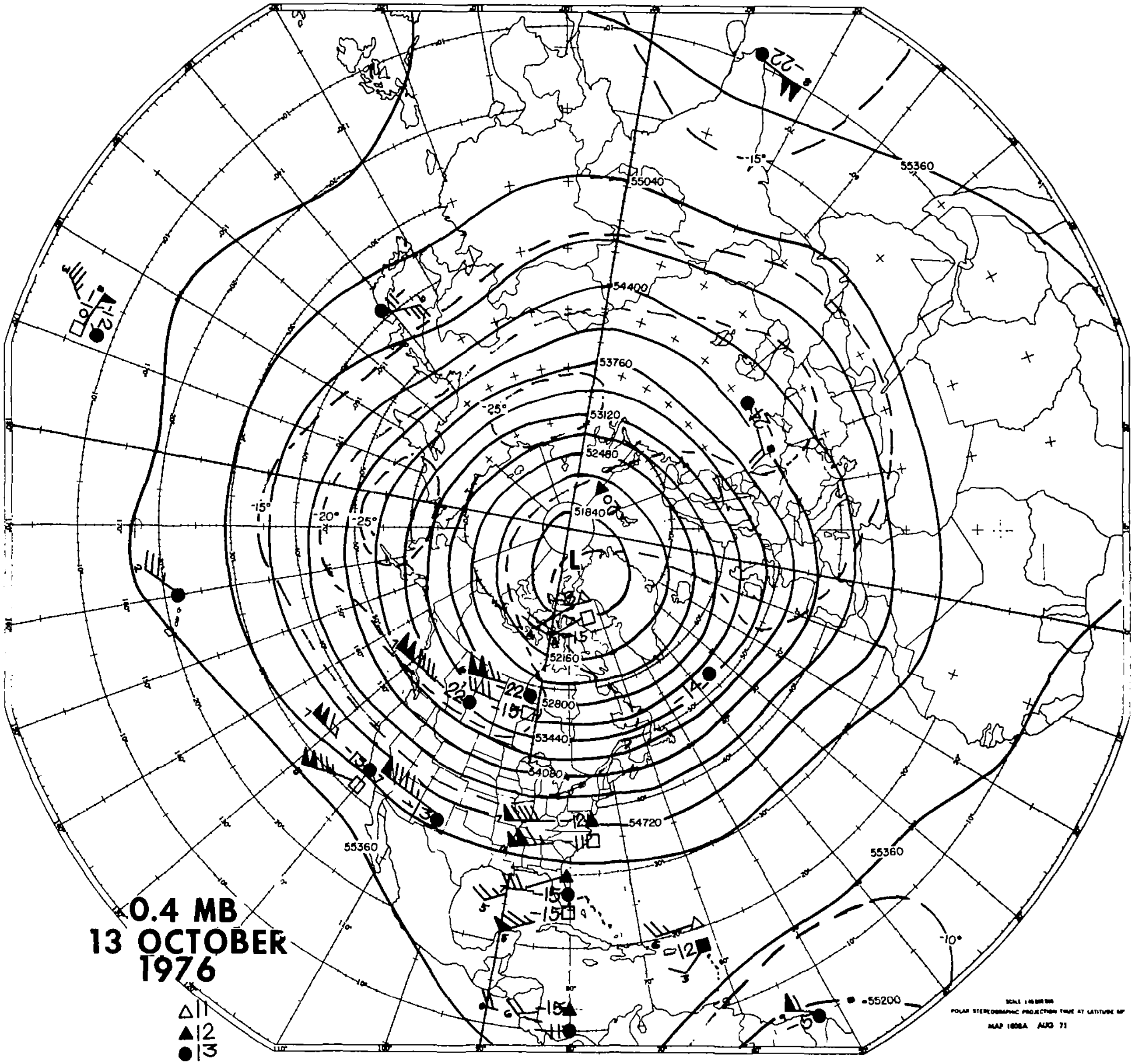
MAP 1808A AUG 71



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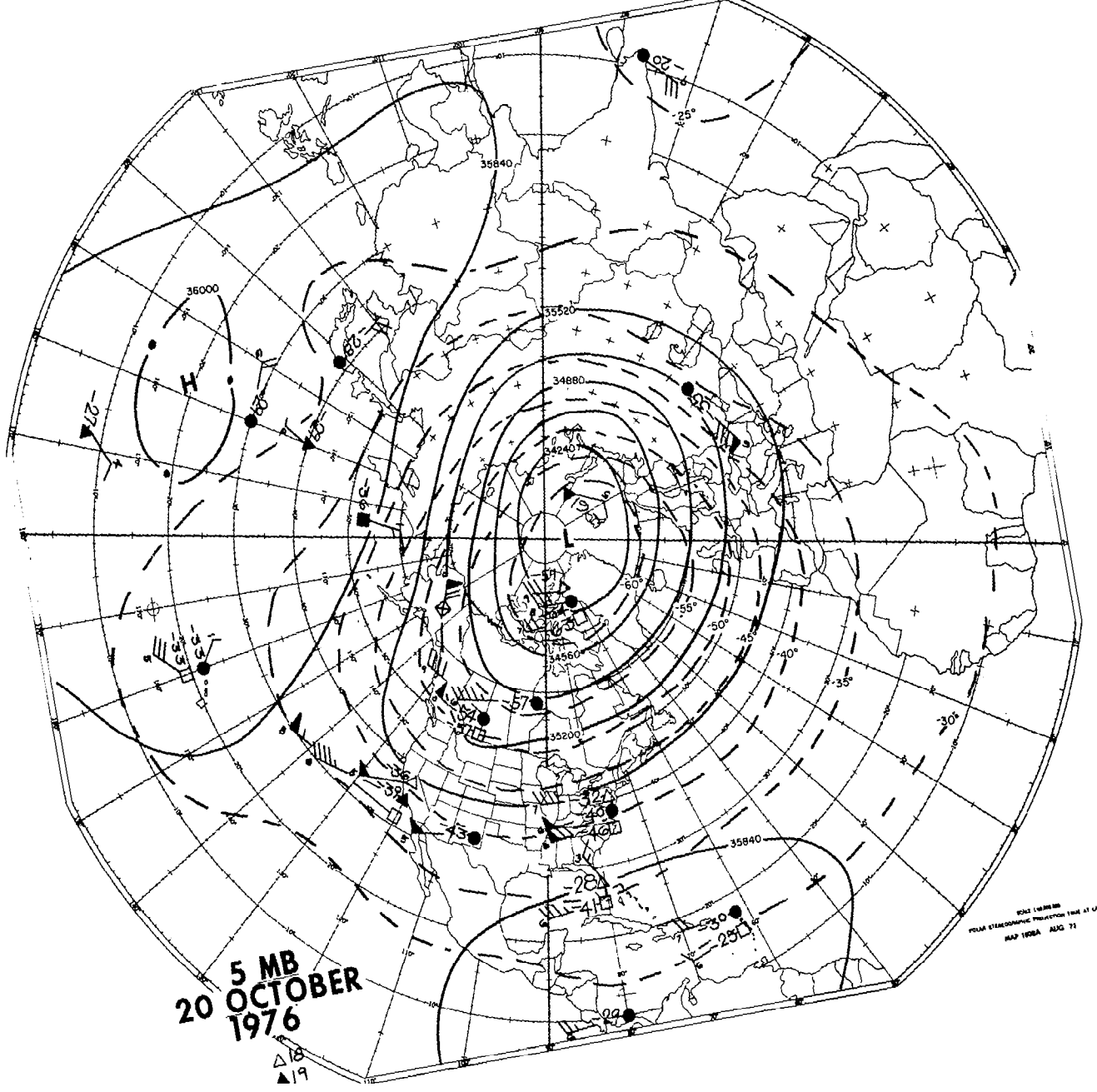
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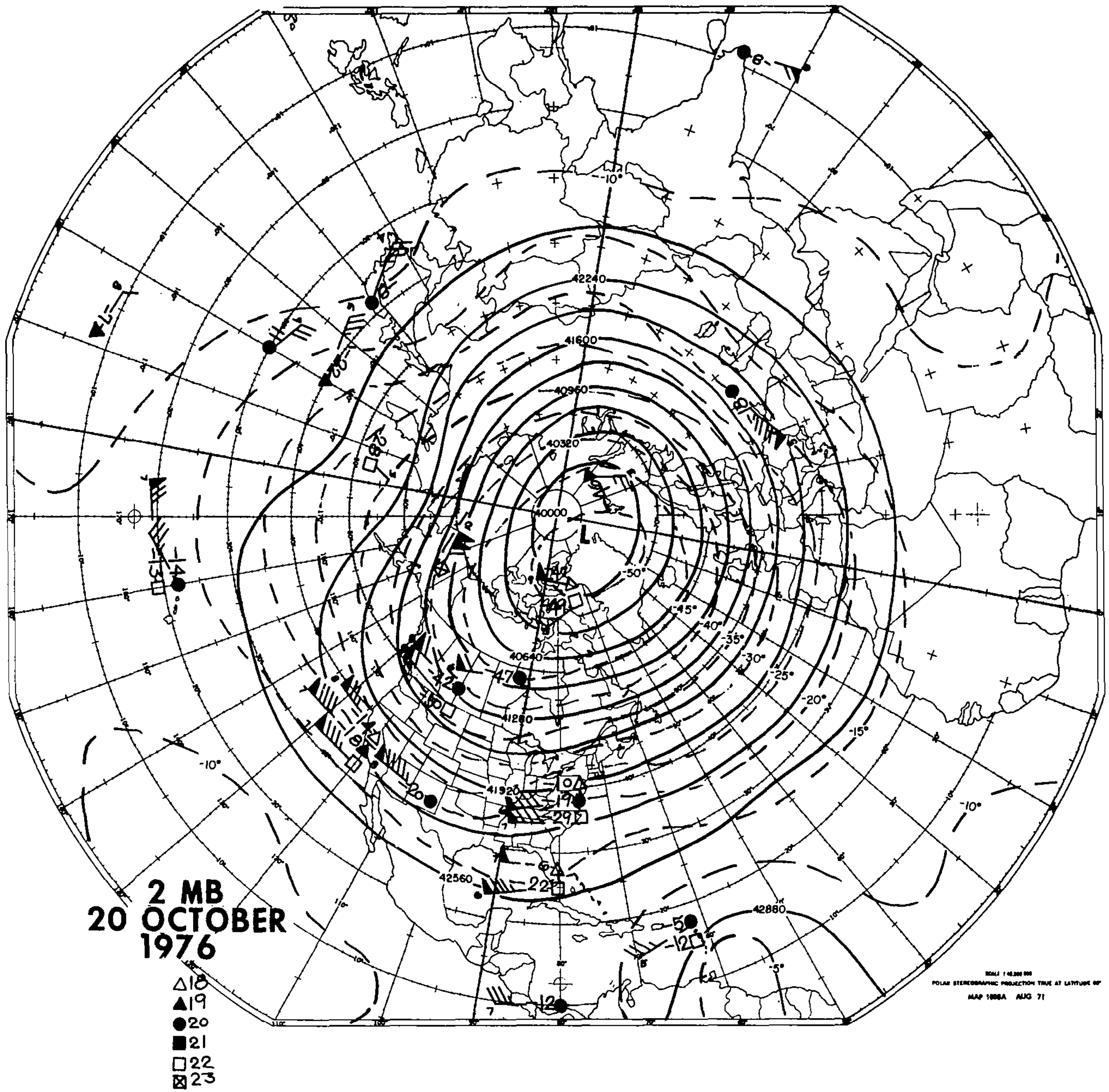

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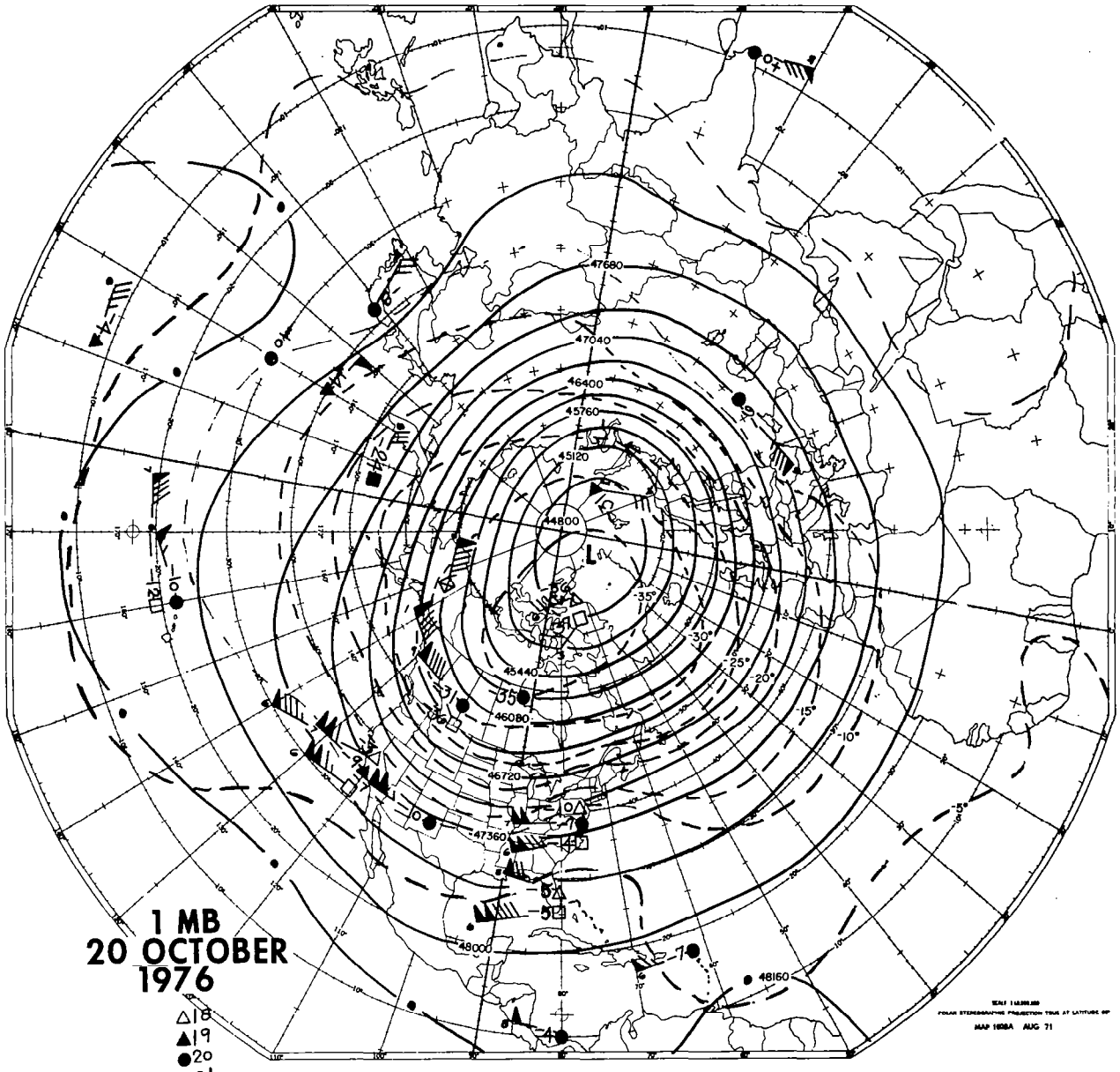

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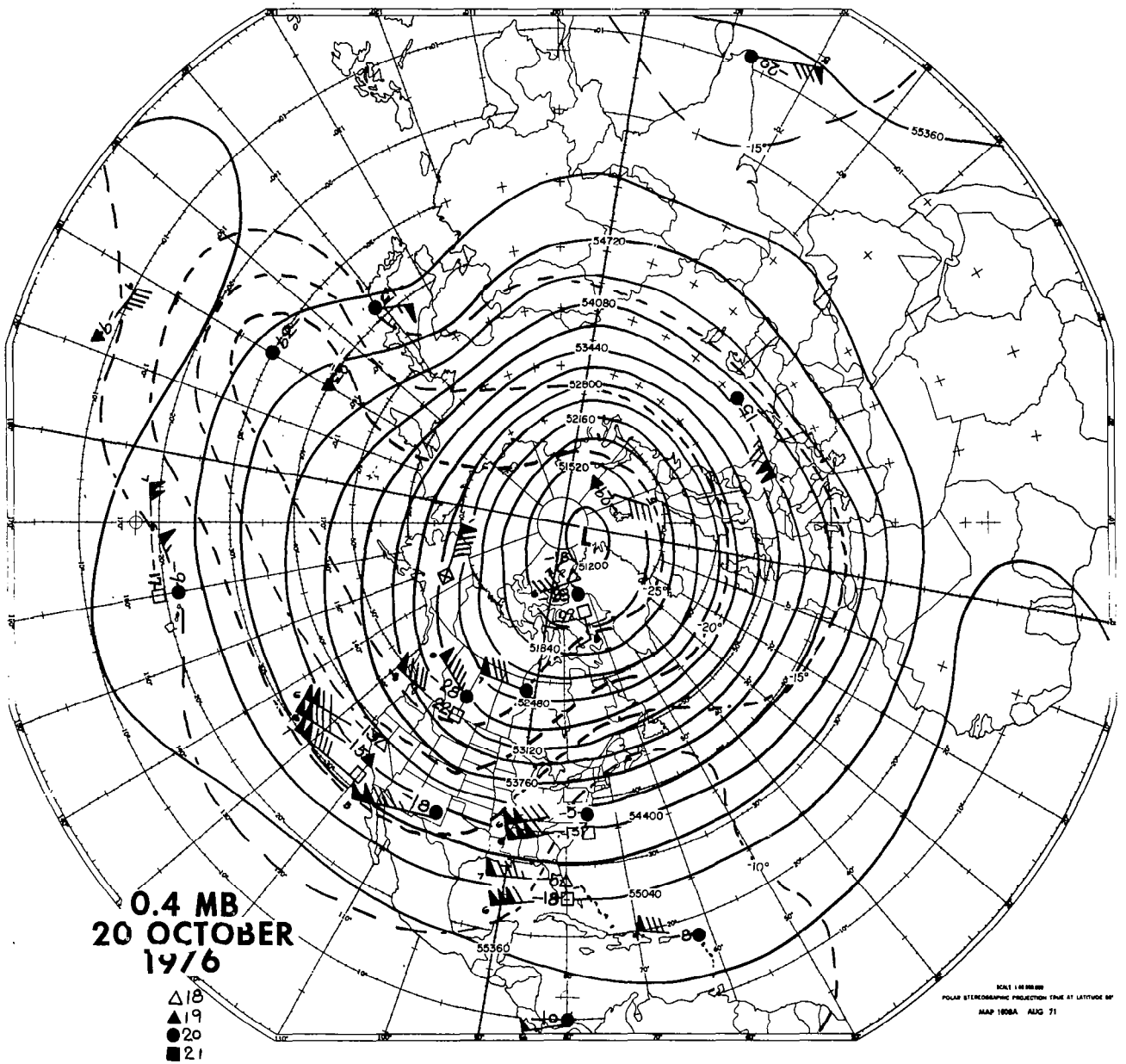
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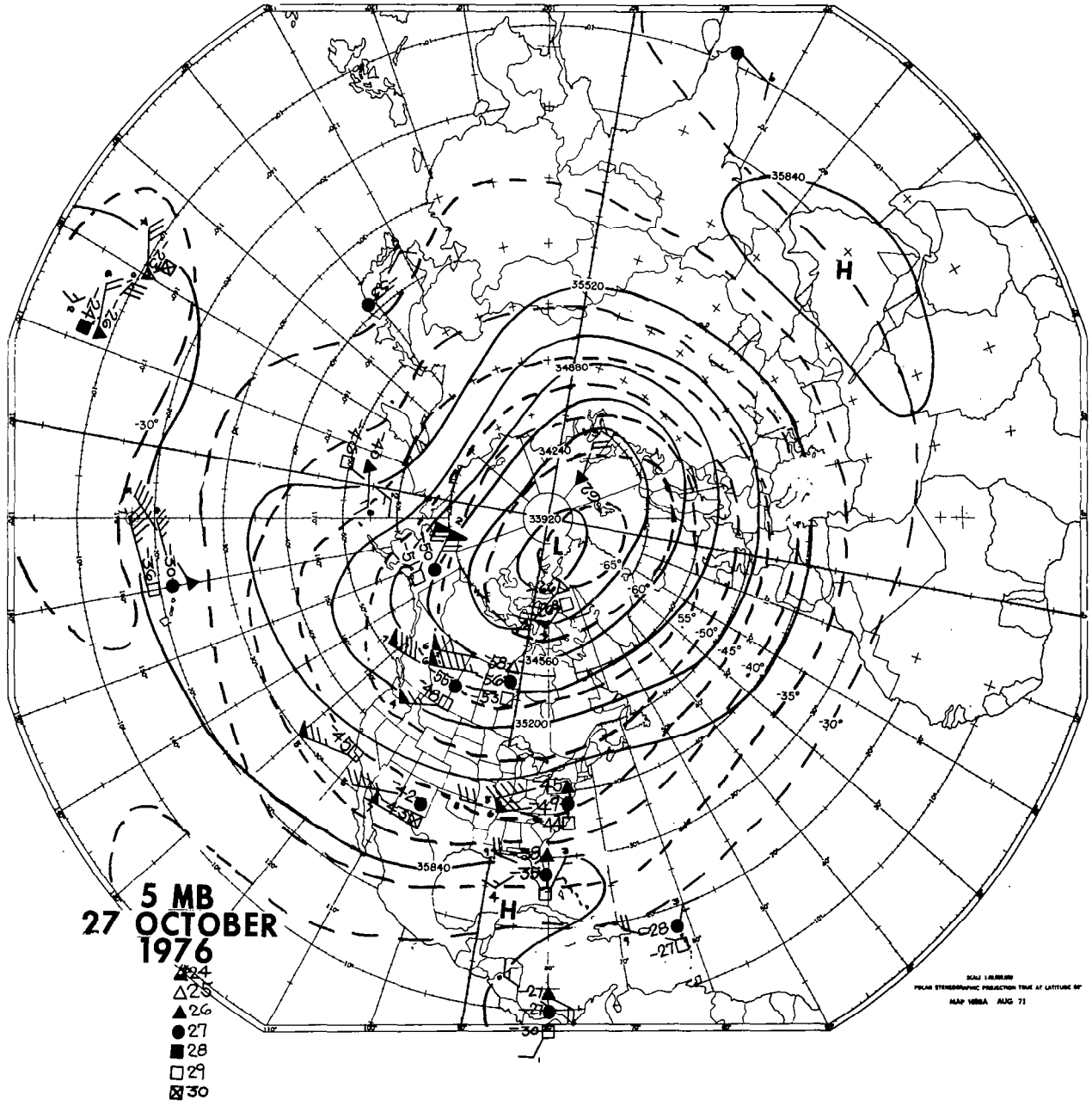
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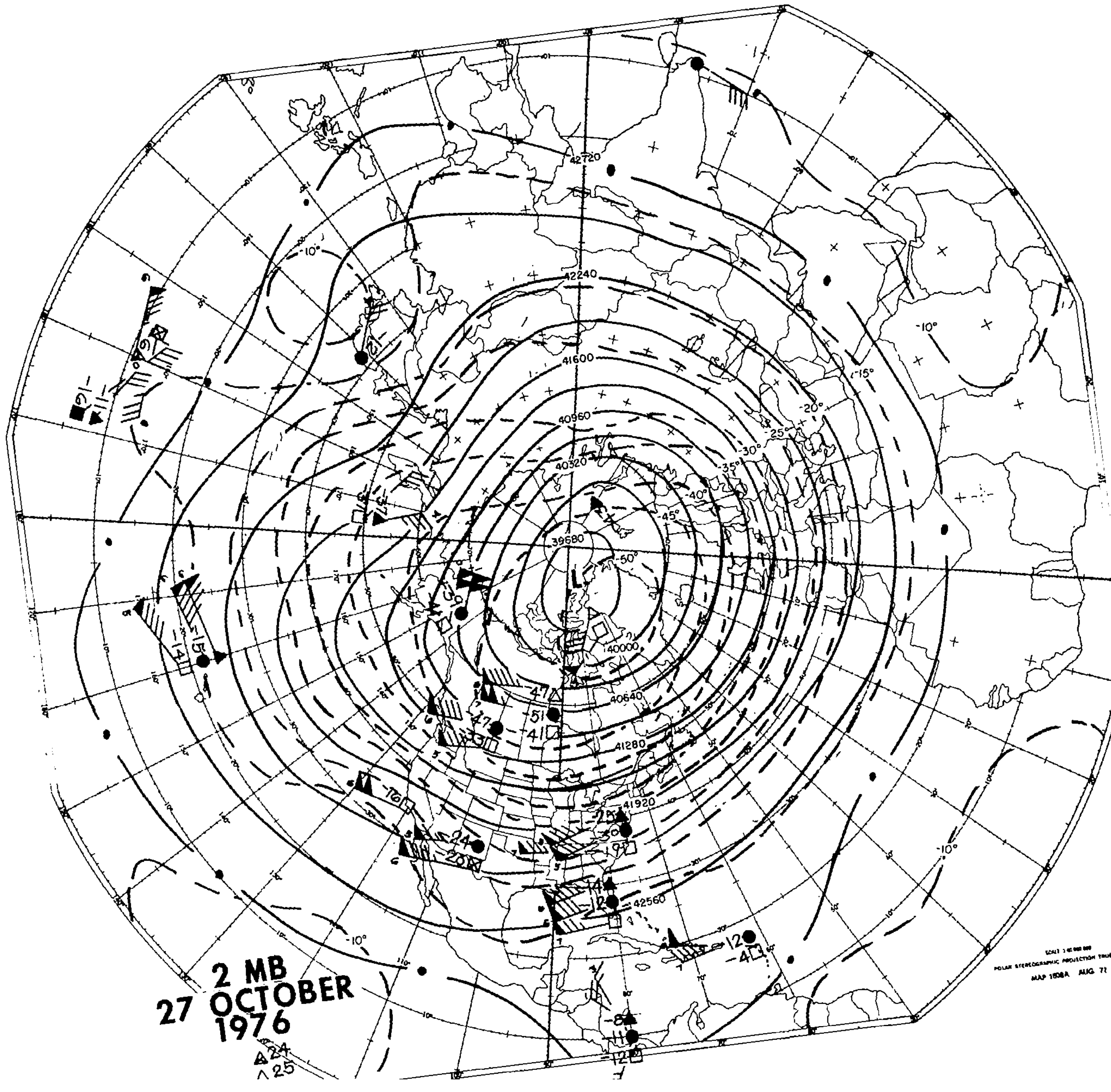
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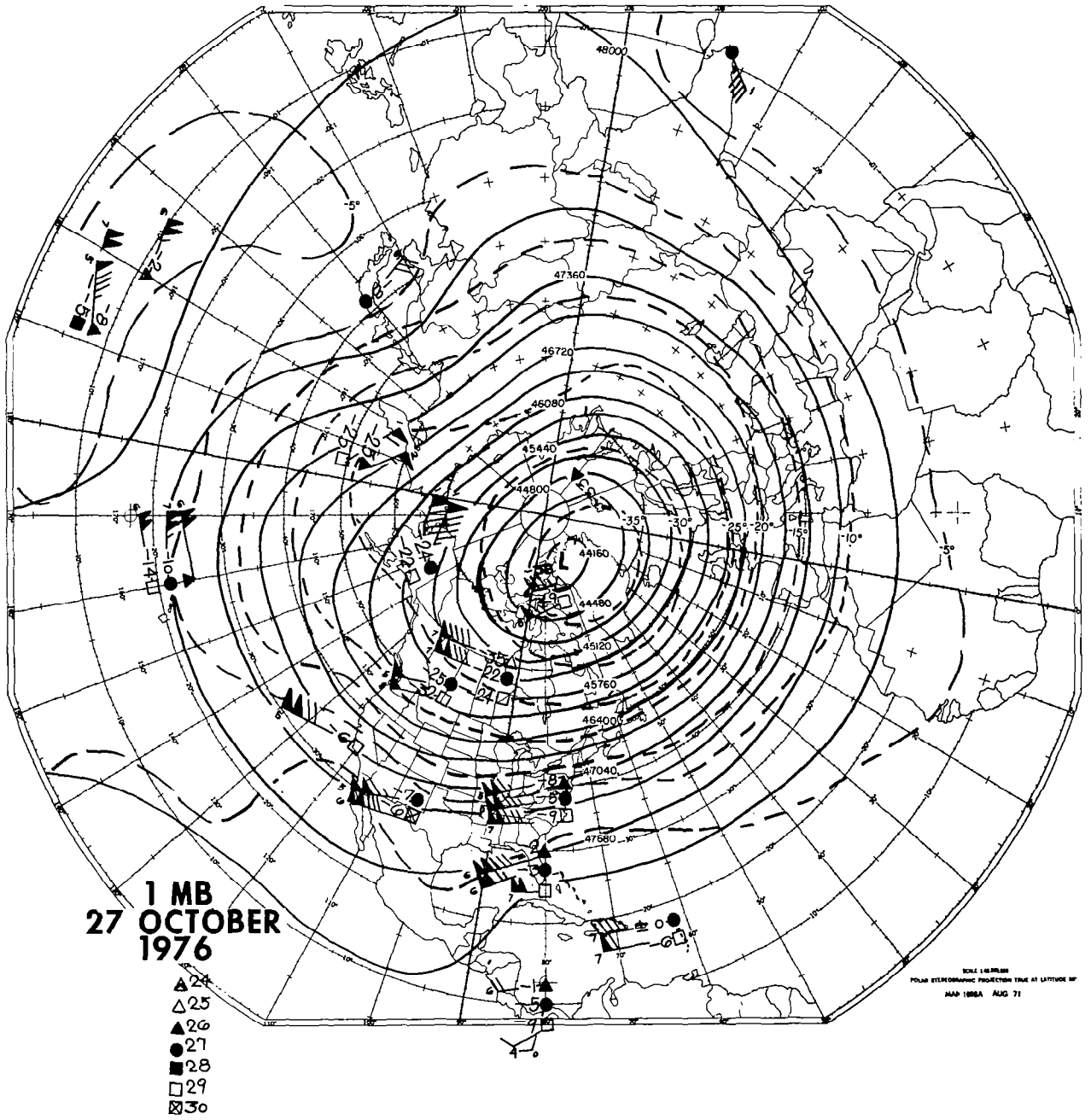
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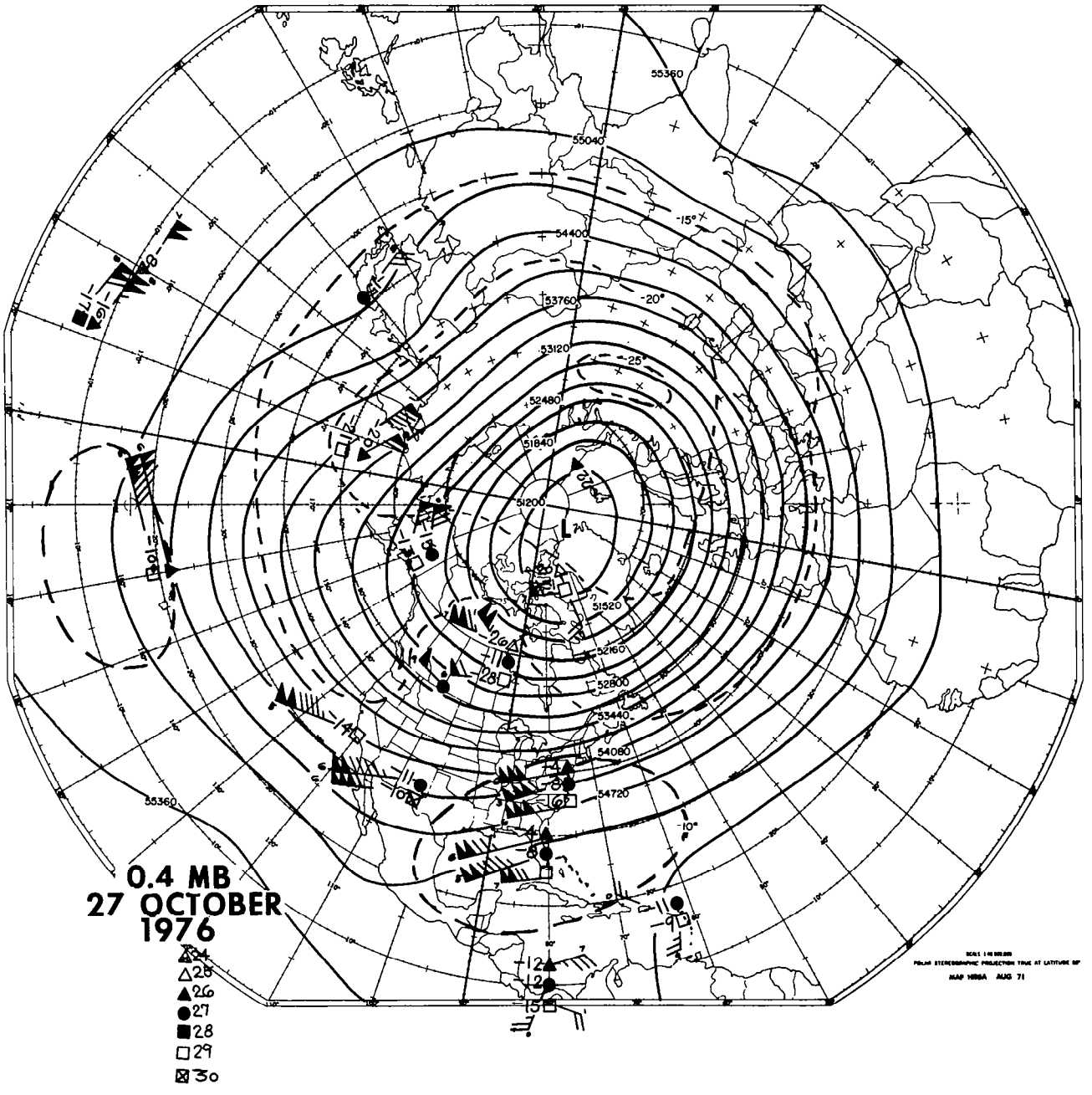
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
AWP 1686A AUG 71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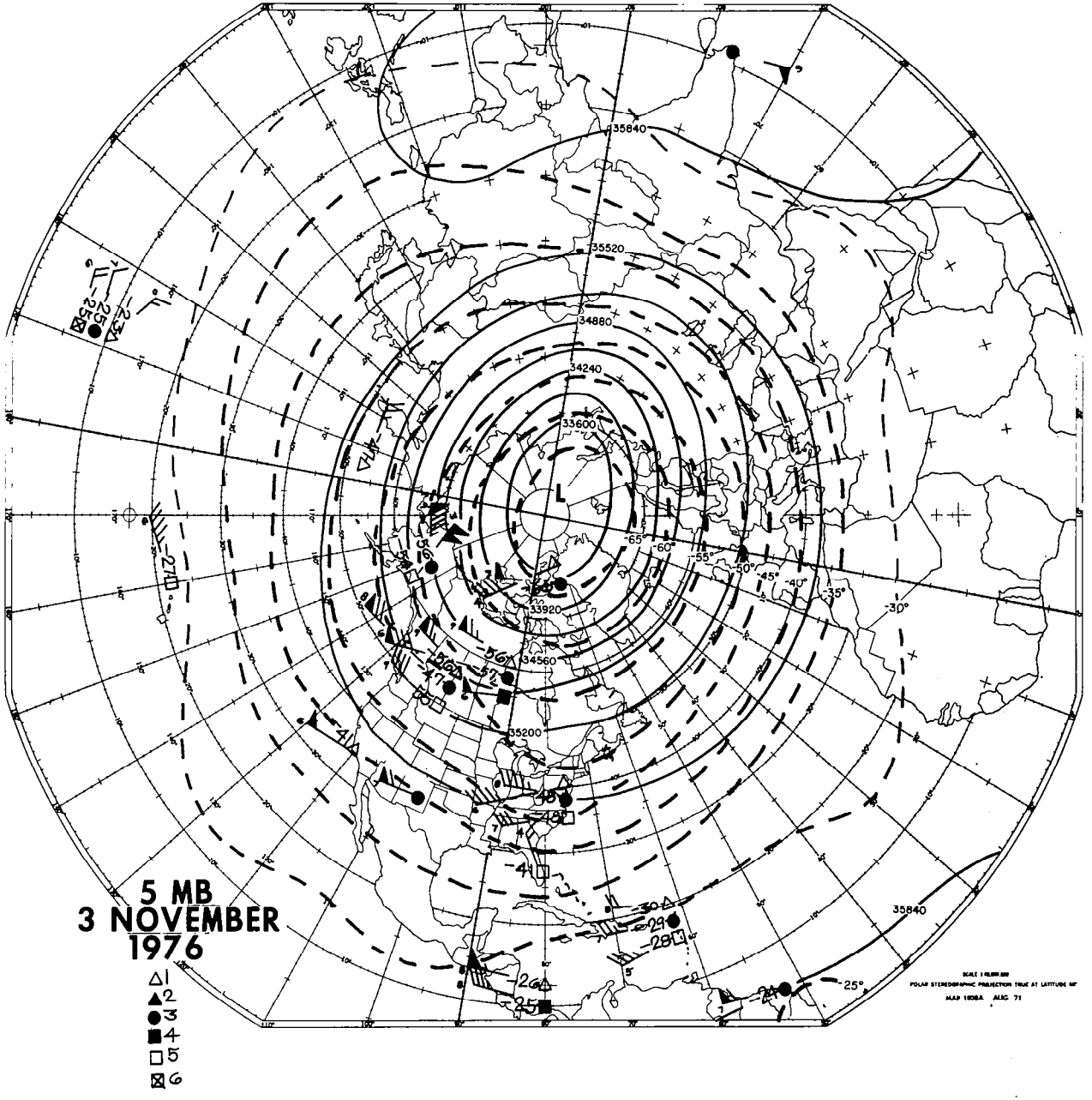
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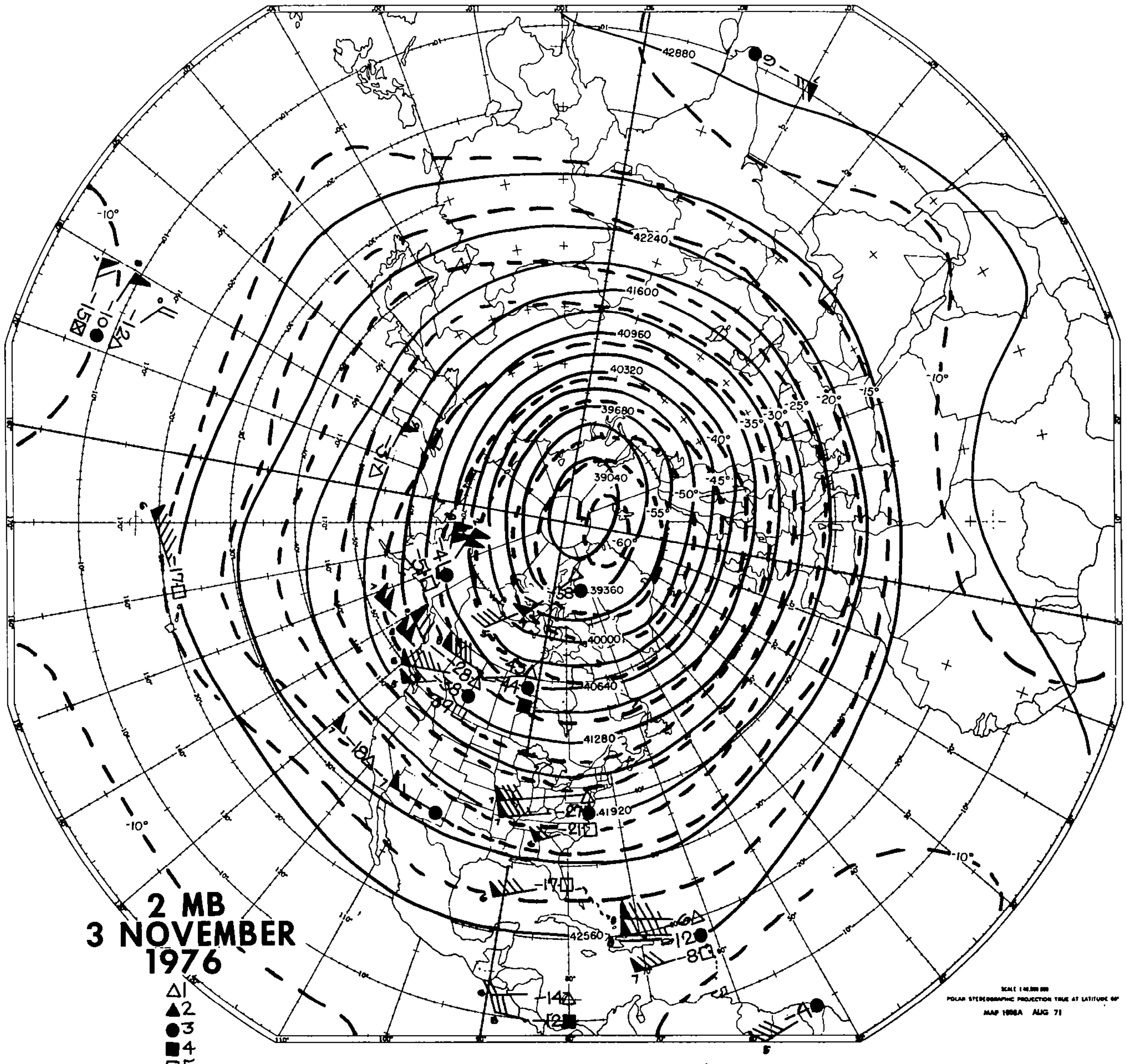

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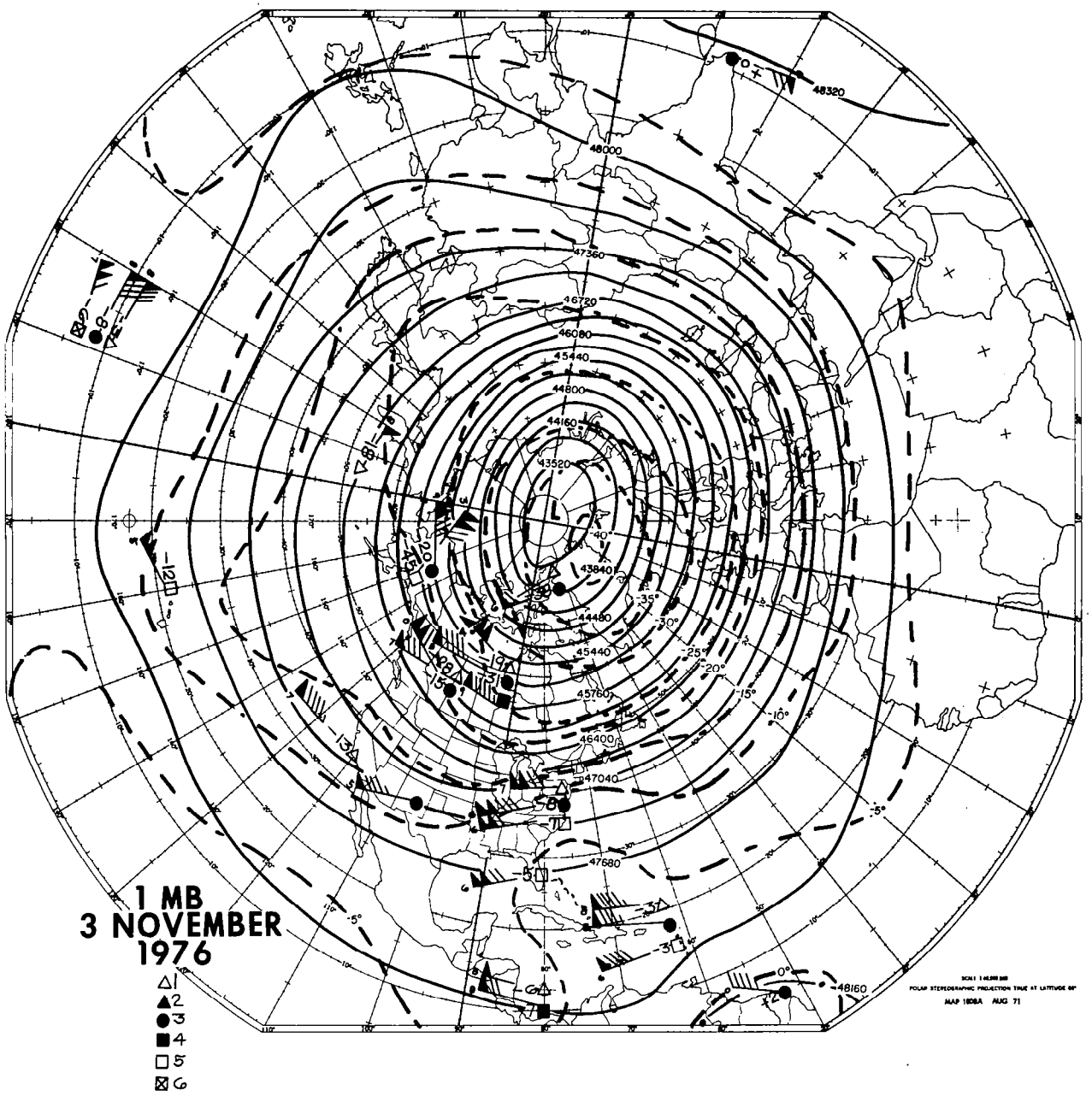
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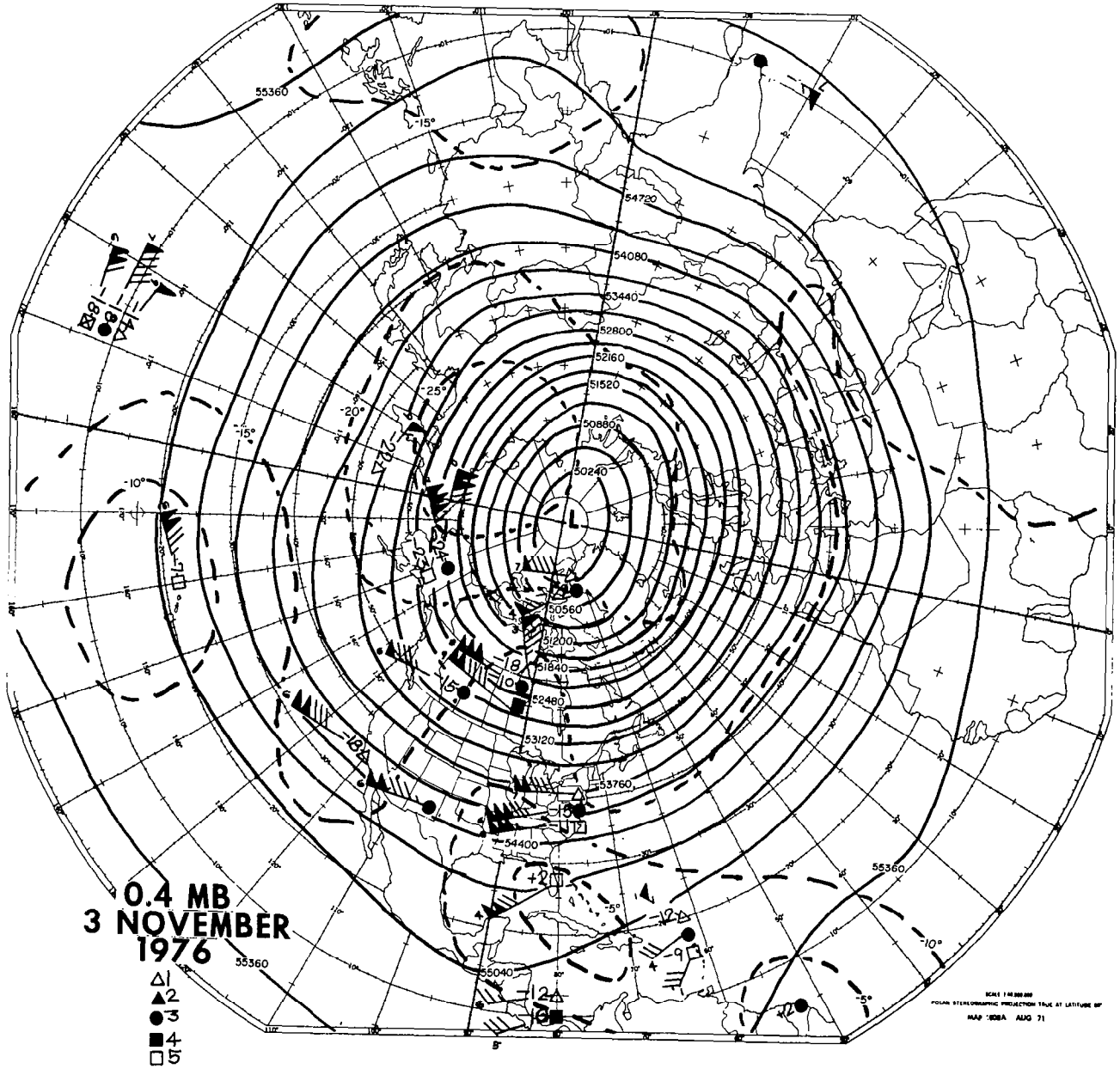
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1808A AUG 71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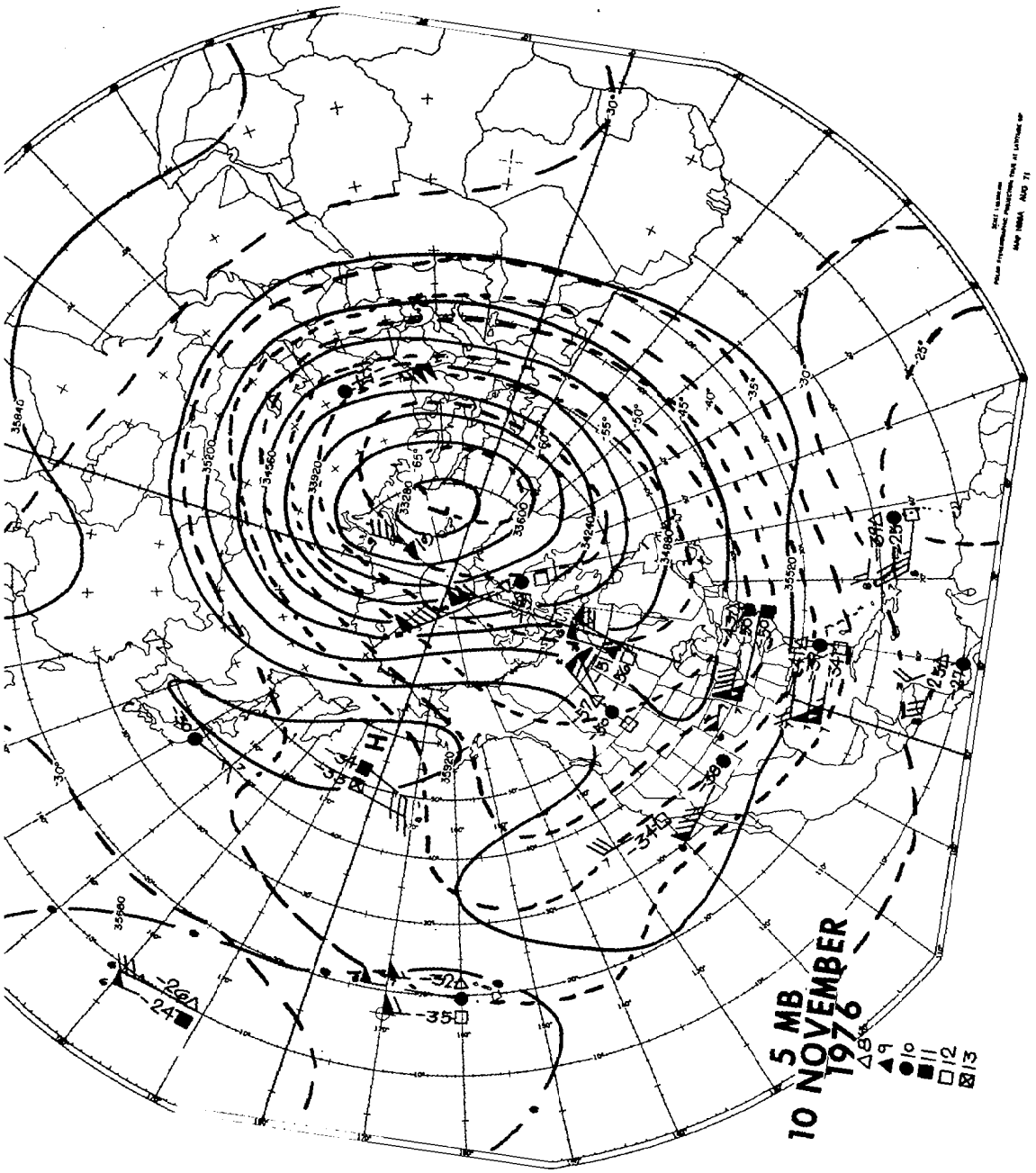
MAP 1808A AUG 71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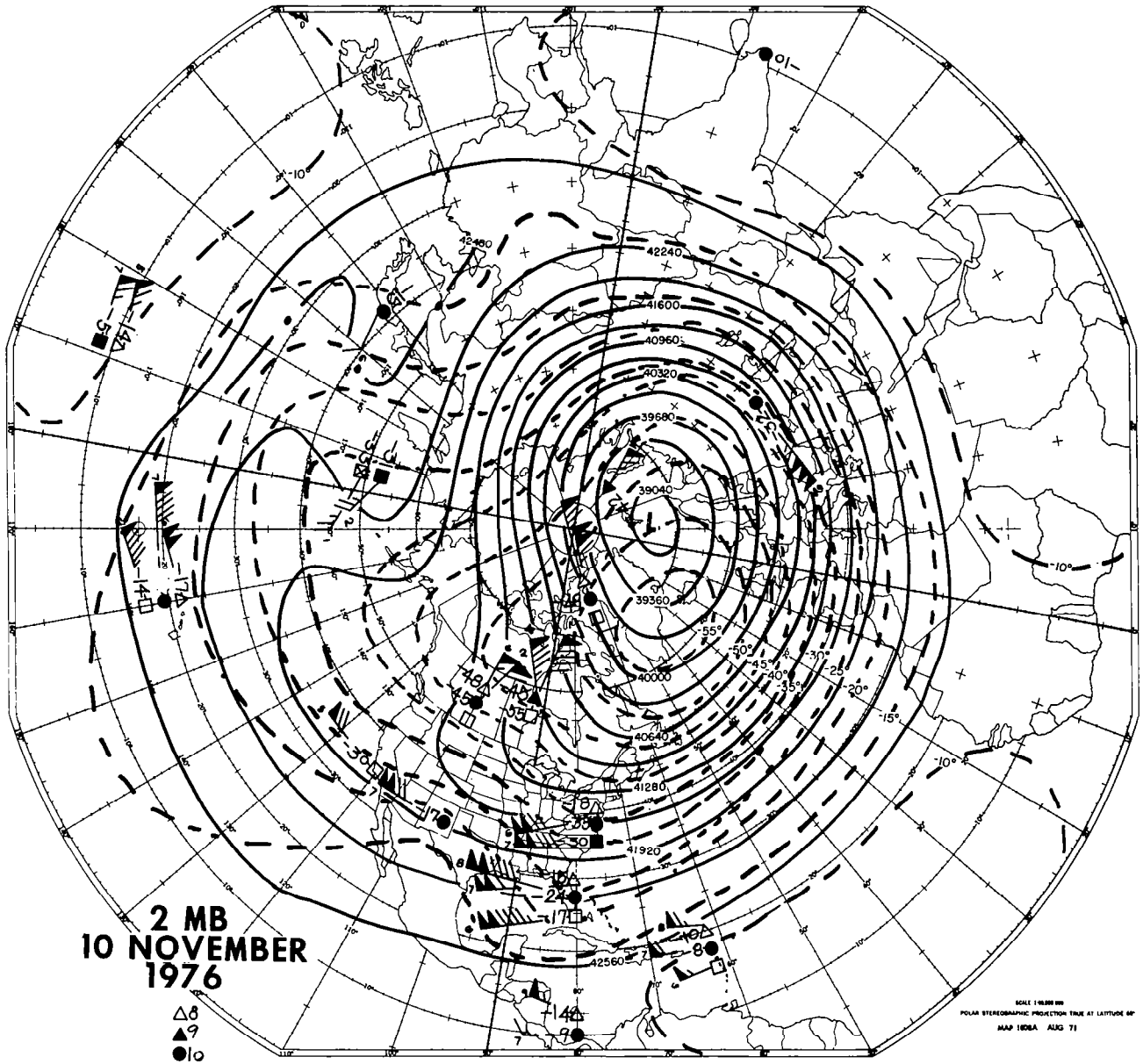
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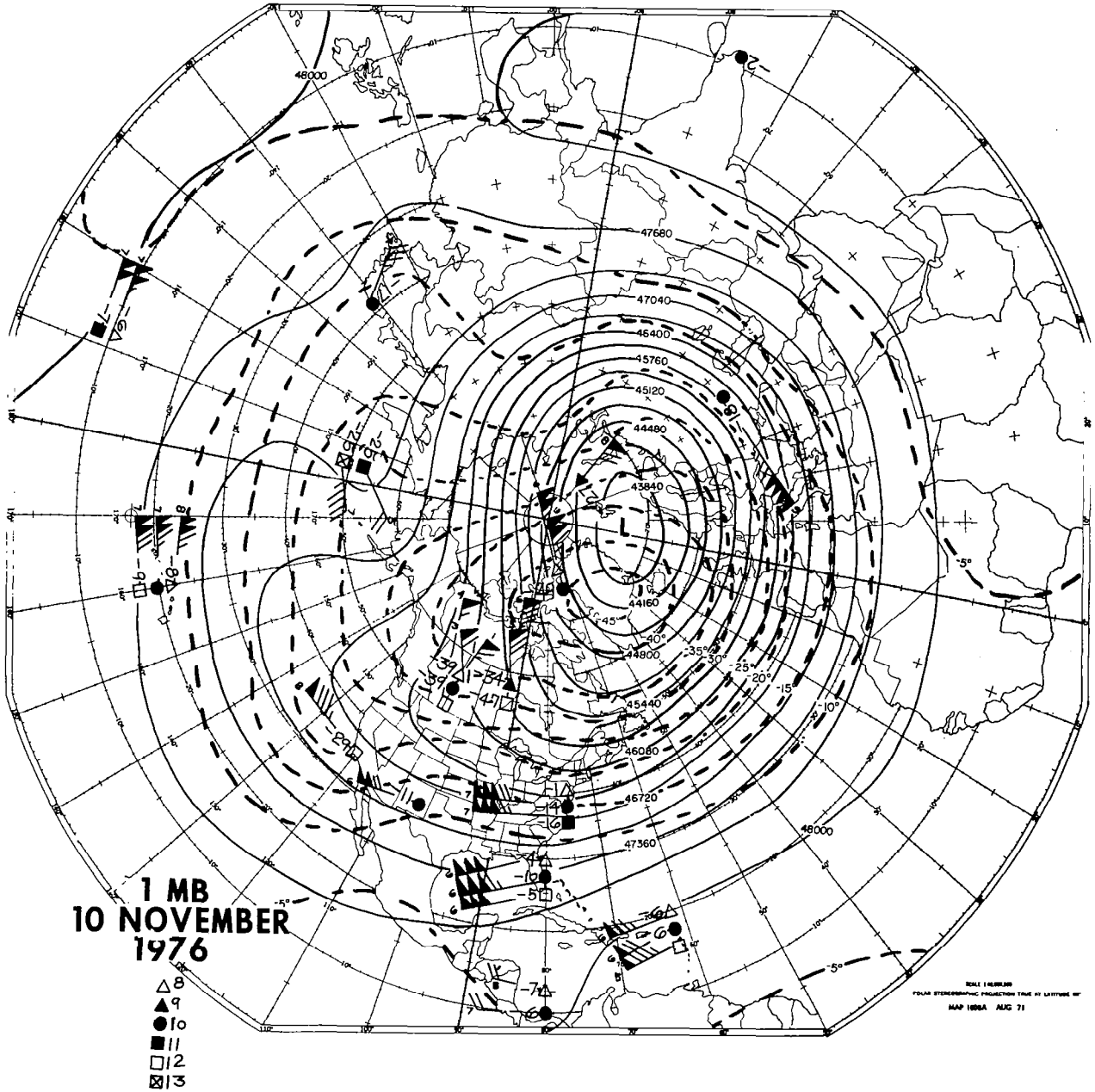
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 160BA AUG 71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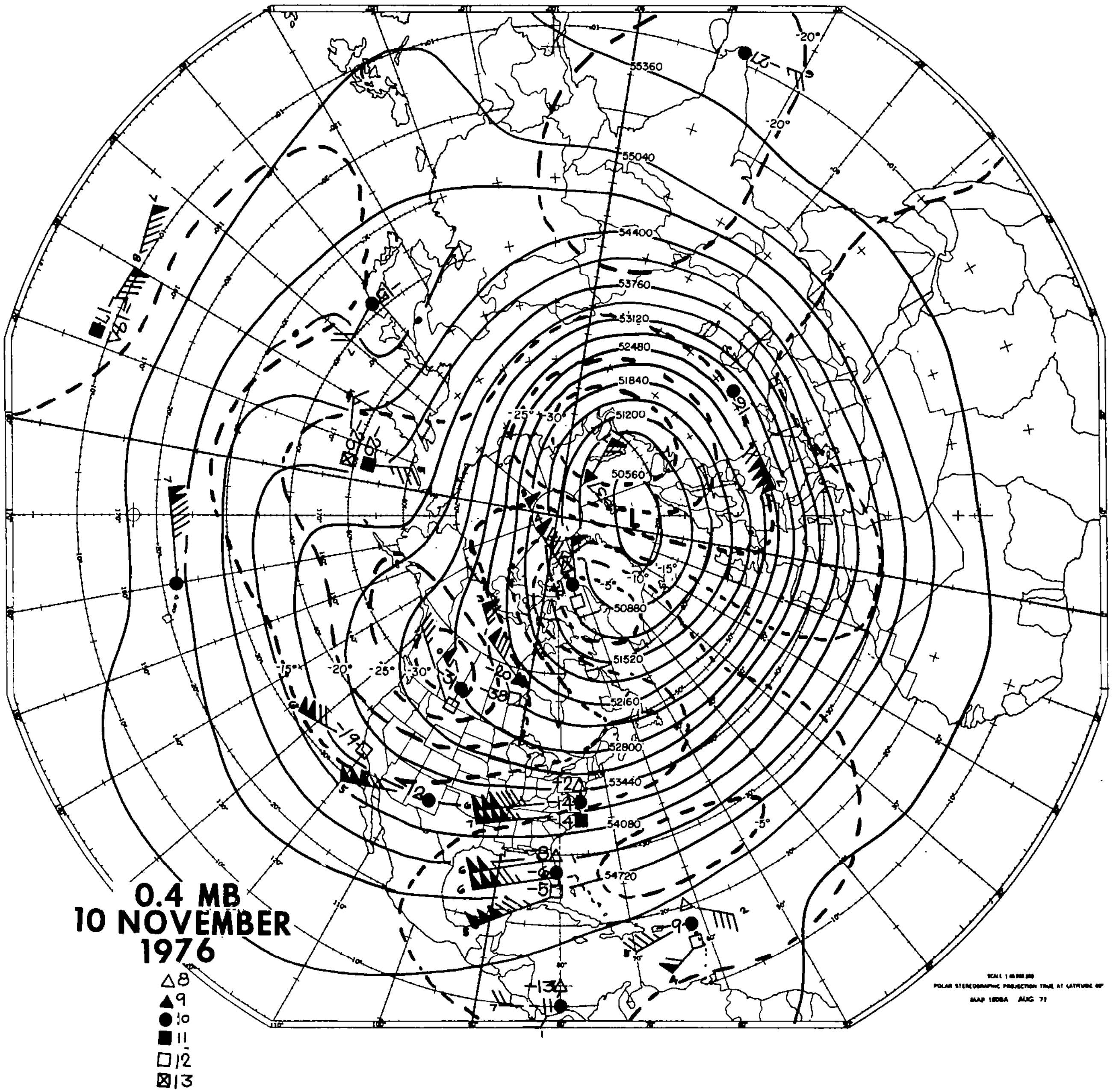
MAP 1698A AUG 71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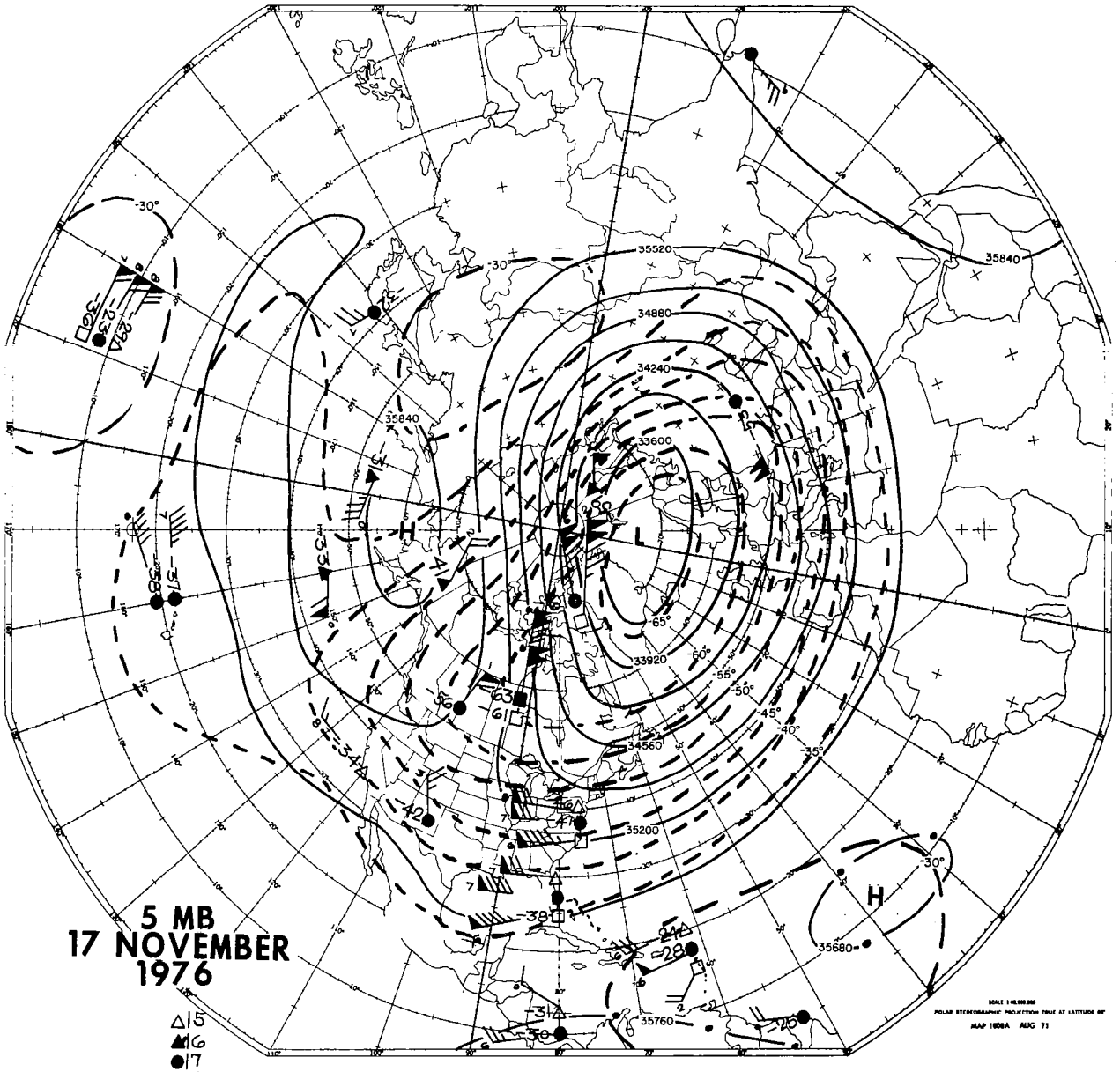
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1608A AUG 71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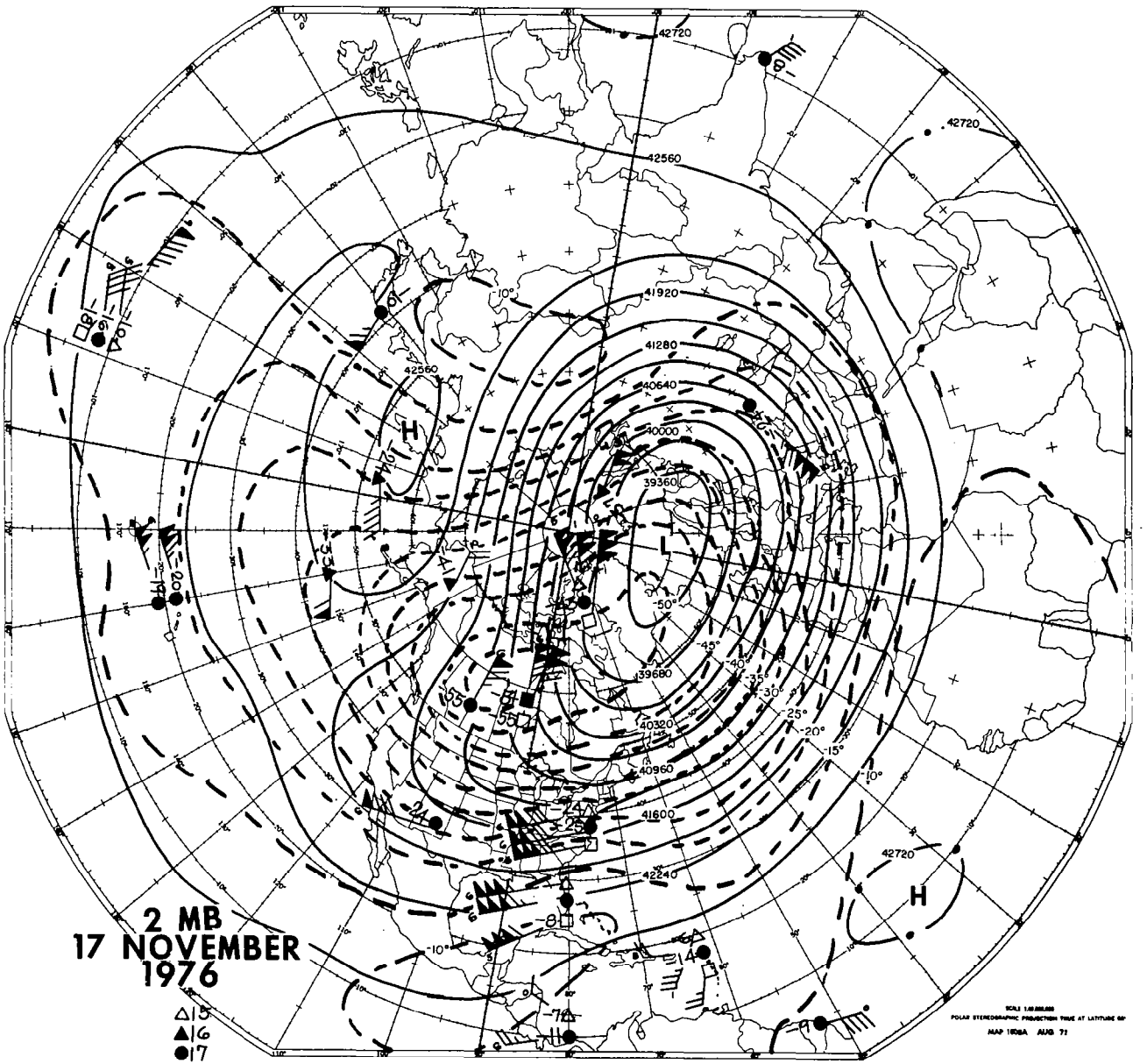
MAP 1608A AUG 71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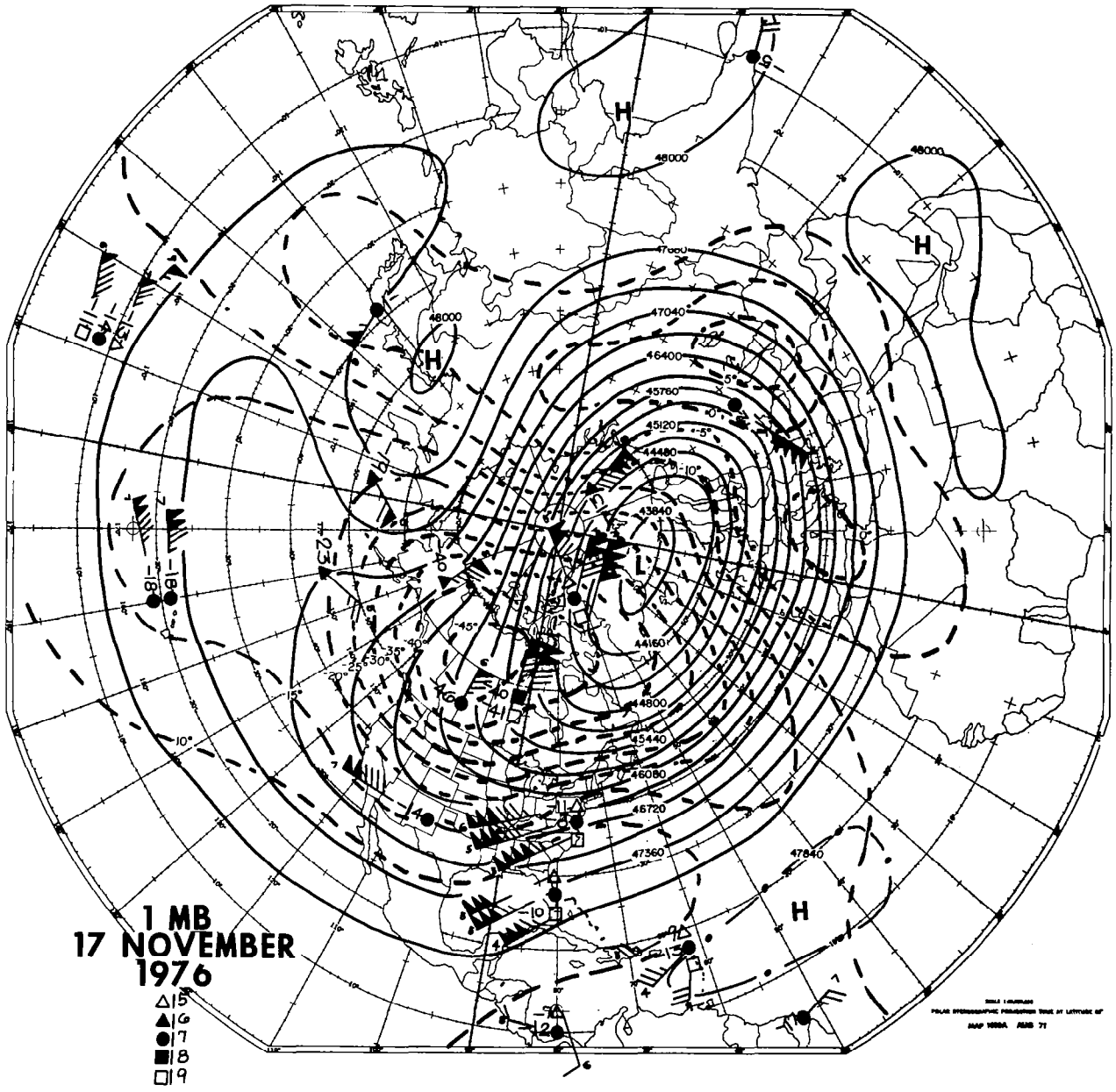
MAP 1606A AUG 71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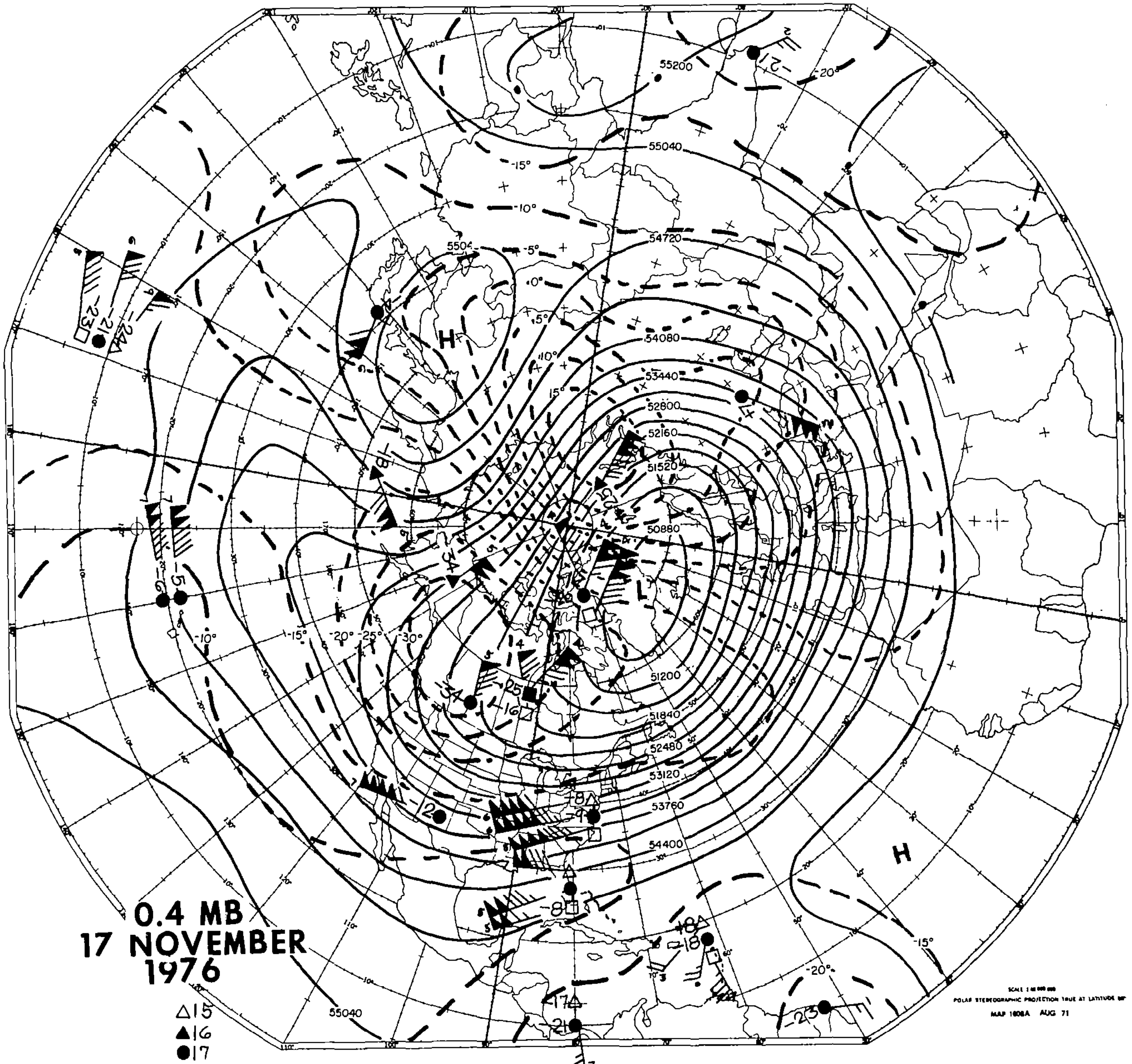

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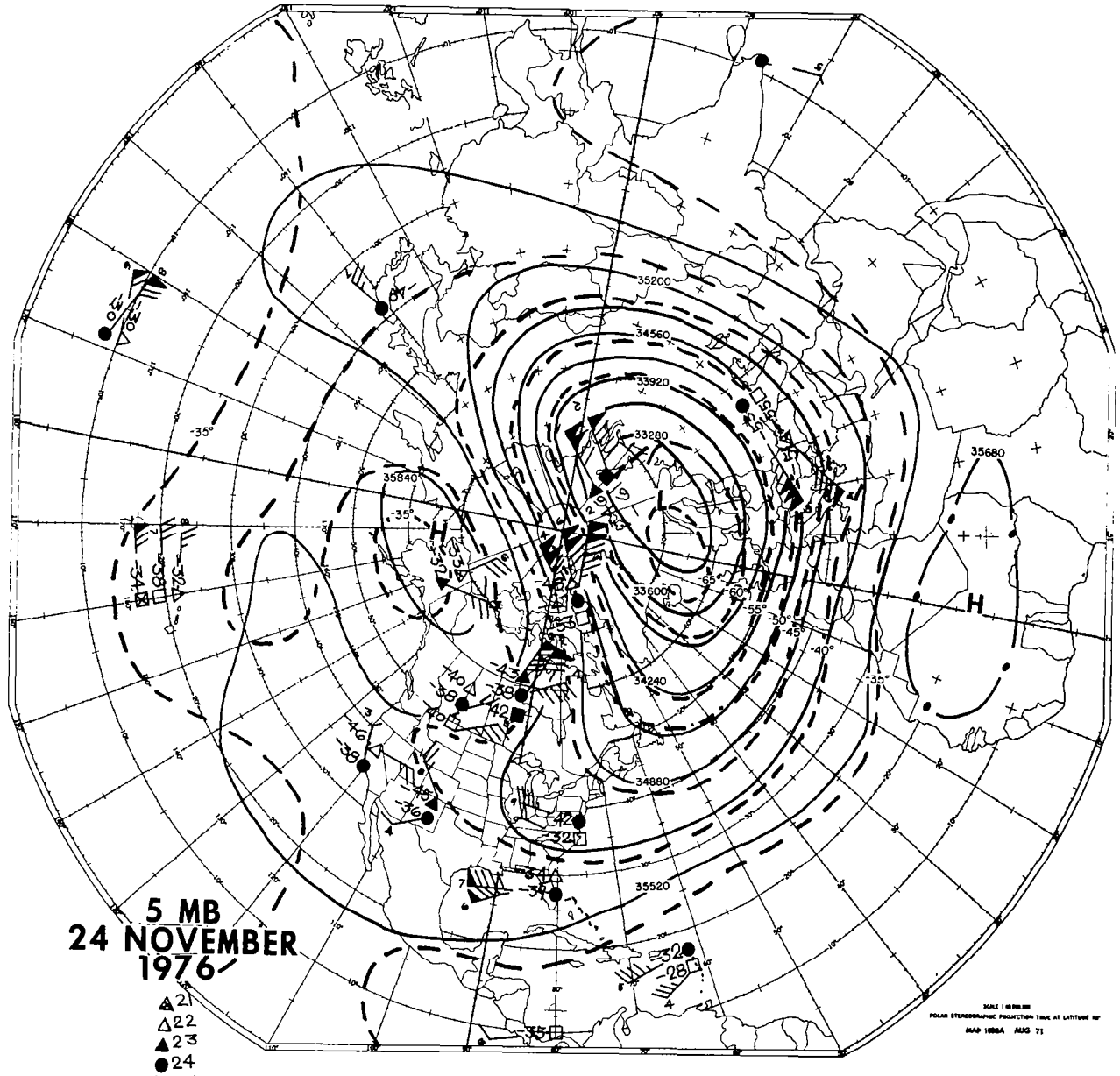
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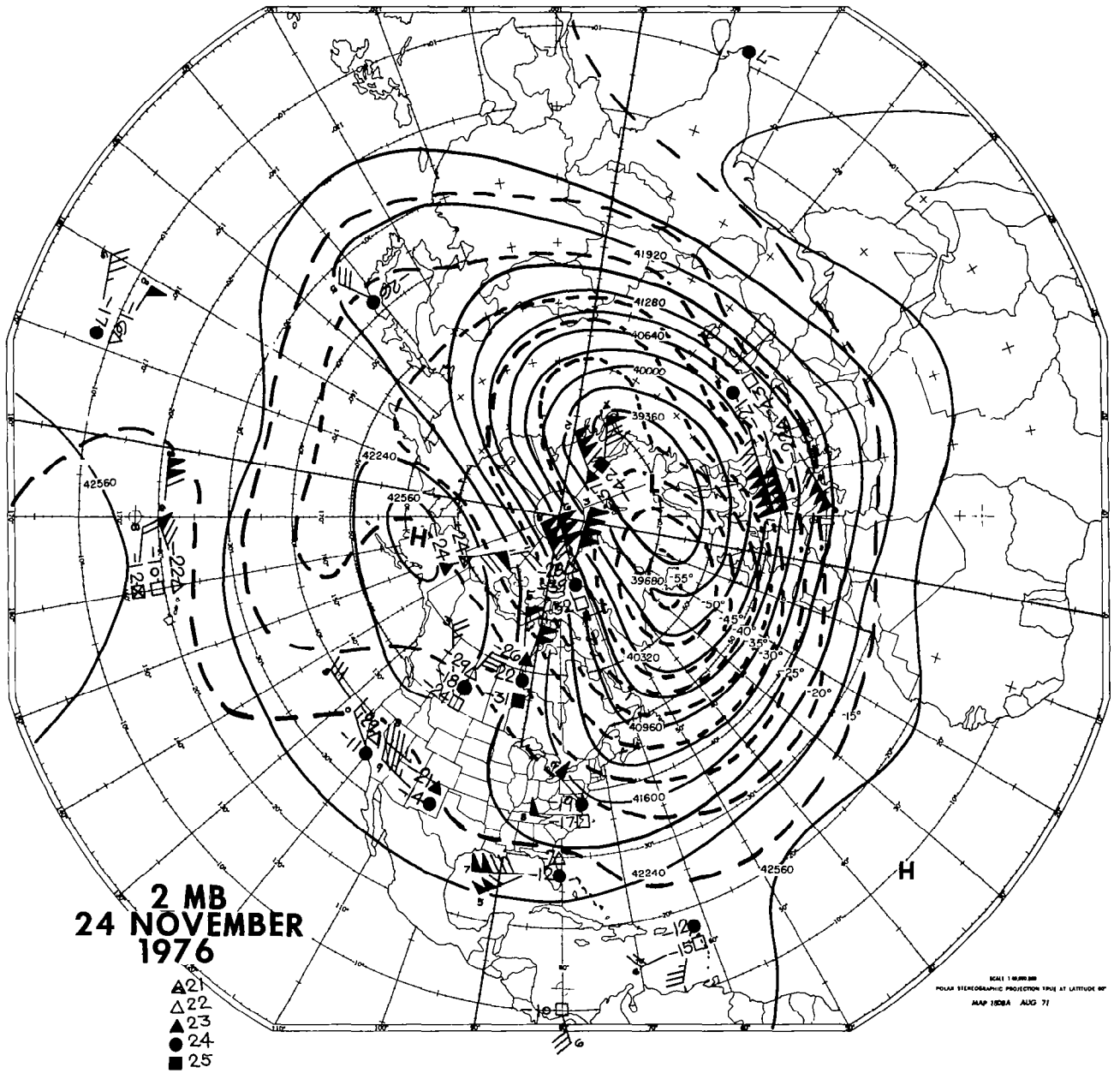
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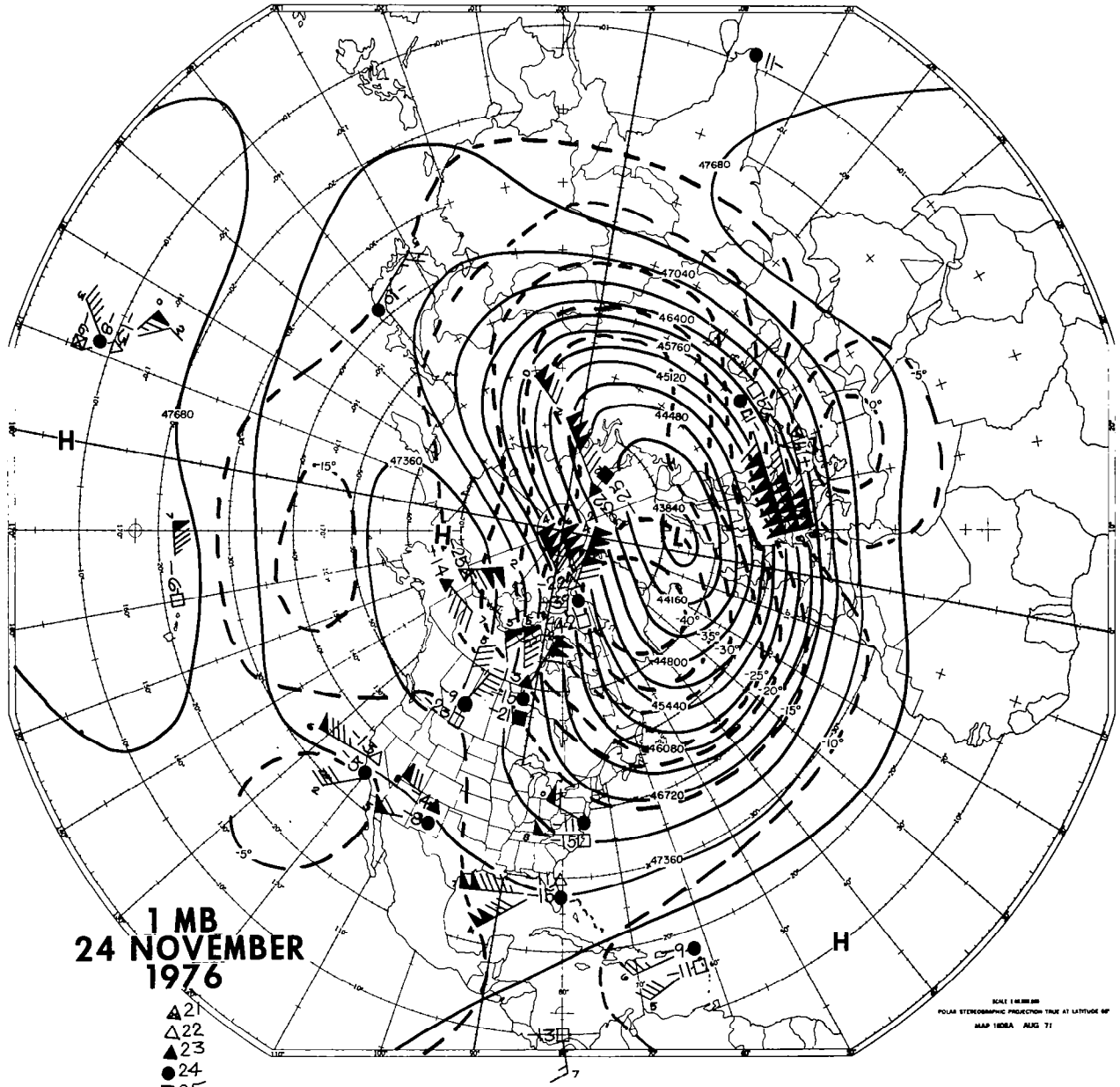
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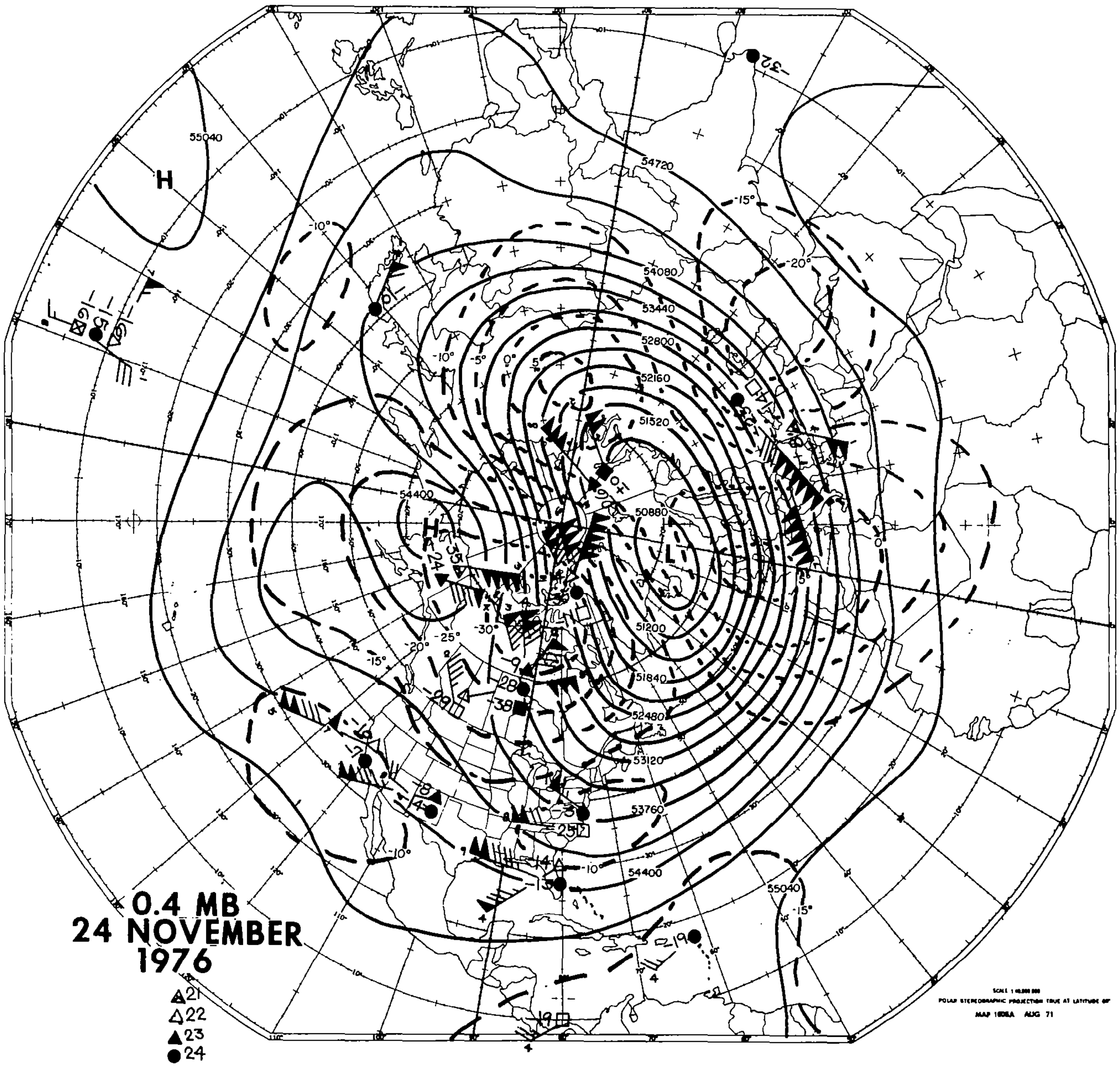
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 180BA AUG 71



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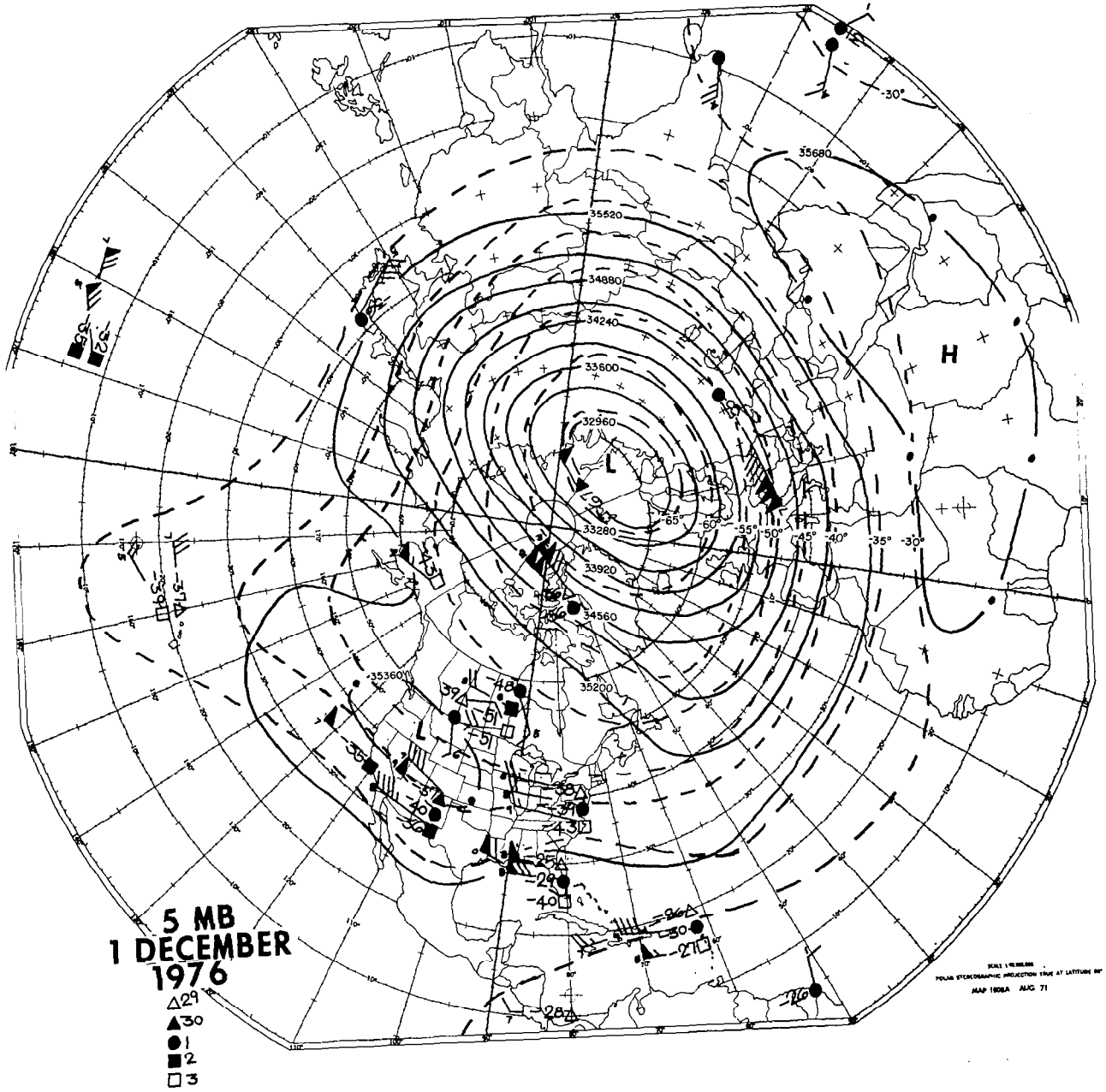
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34560
35200
35360
H
L
L
L
-30°
-35°
-40°
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Δ29
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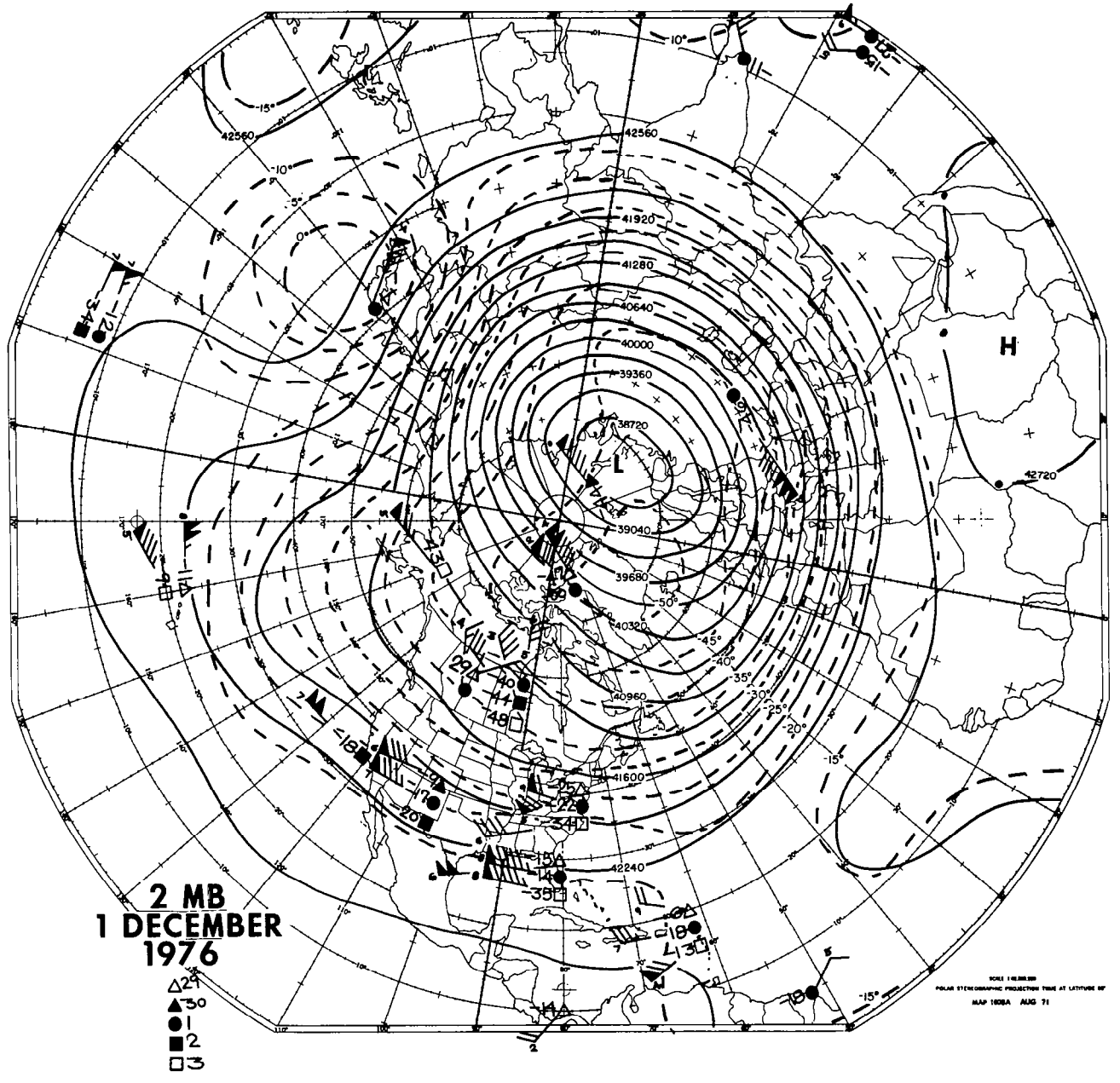
□3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Δ29
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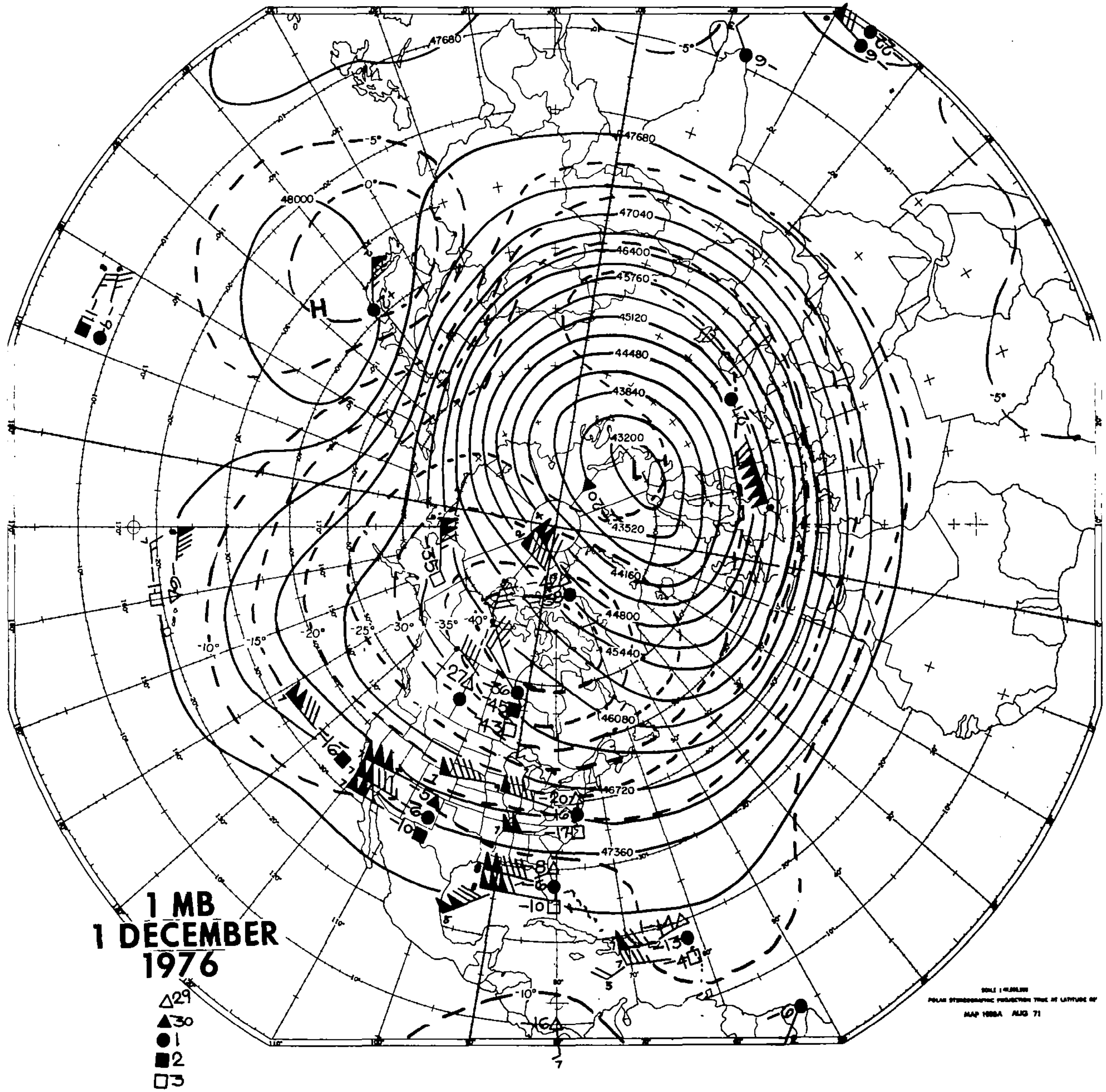
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1608A AUG 71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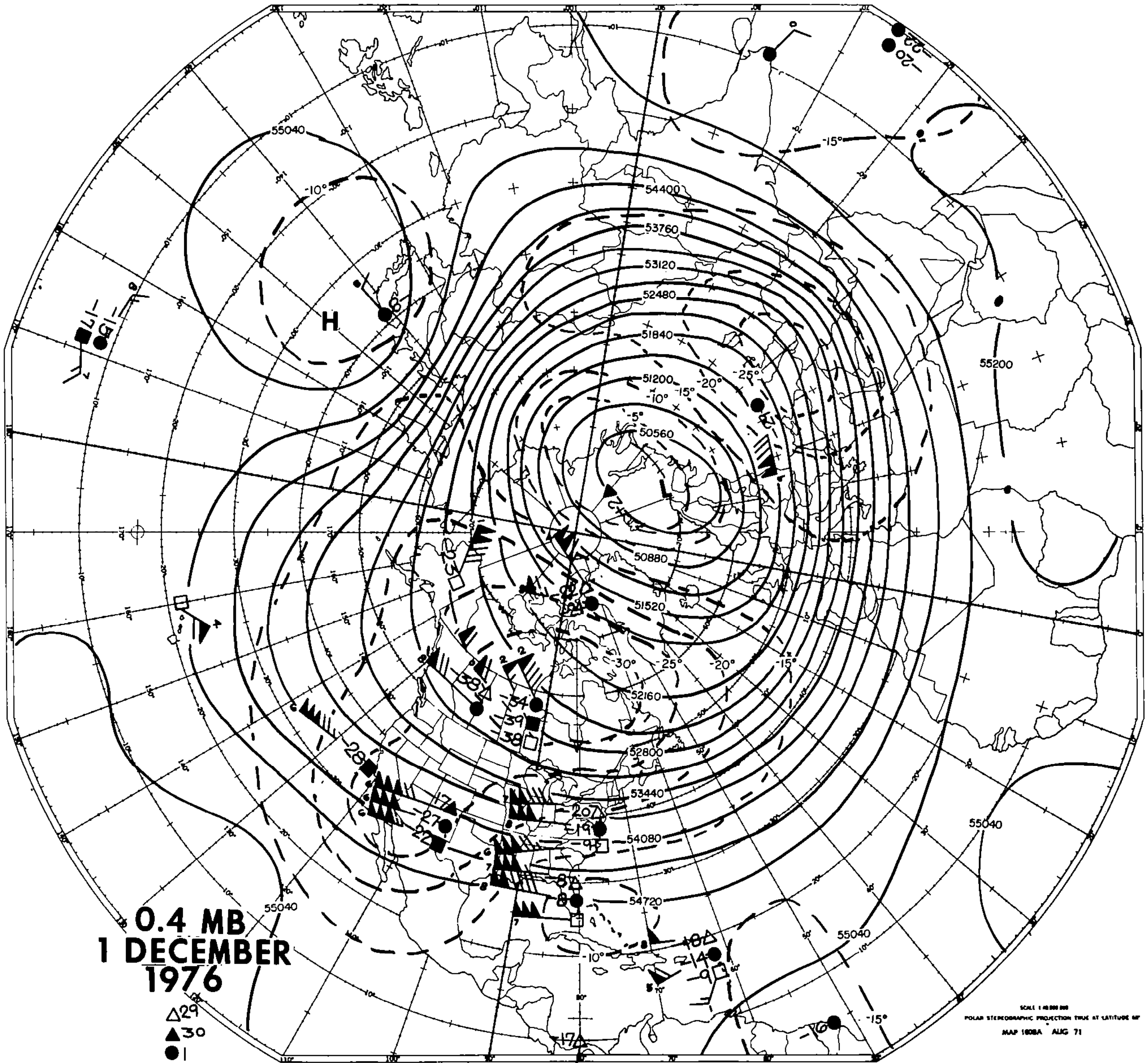
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-10°
-15°
-20°
-25°
-30°
-5°
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POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1608A AUG 71

△29
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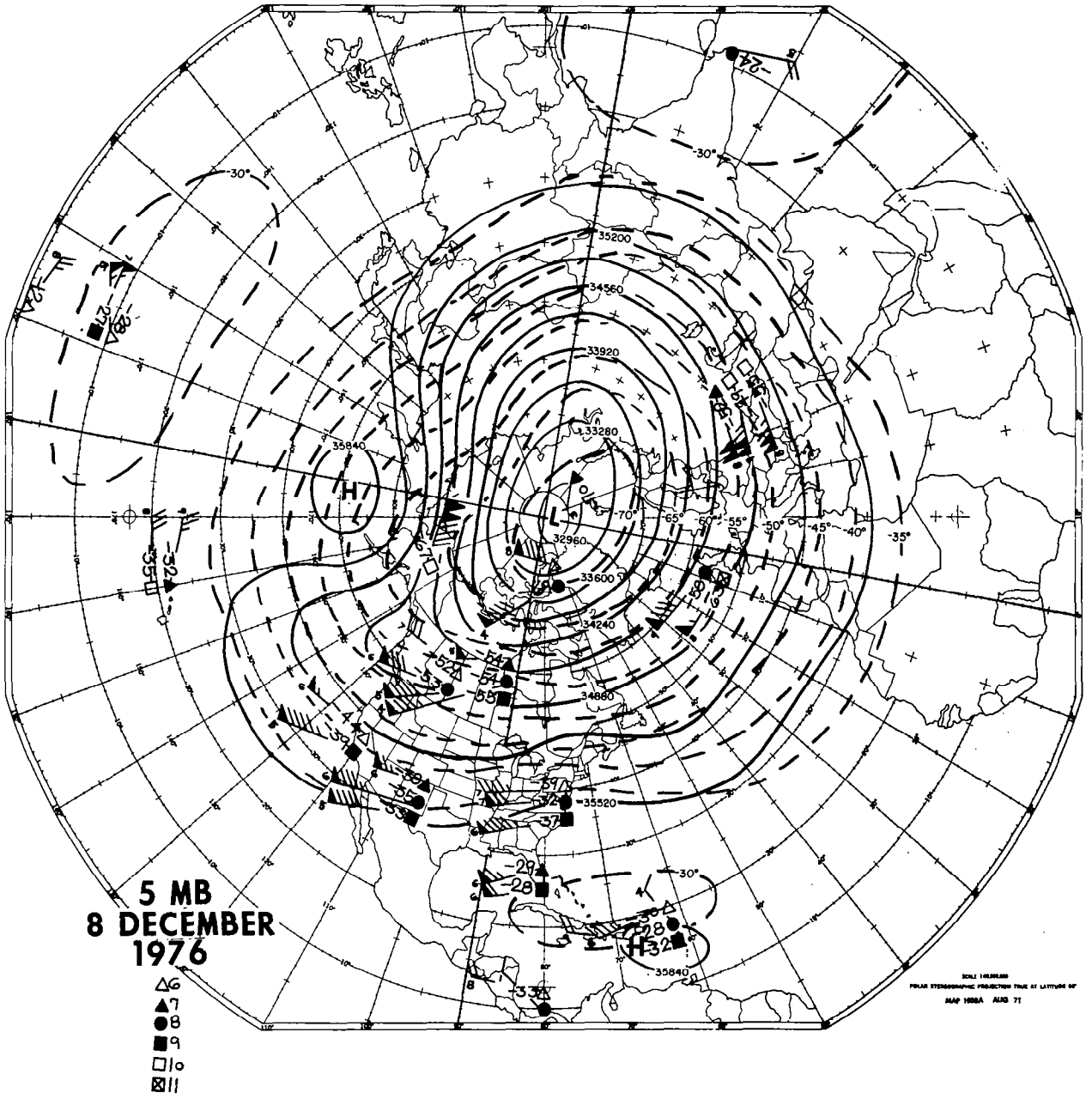
■2
□3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34240
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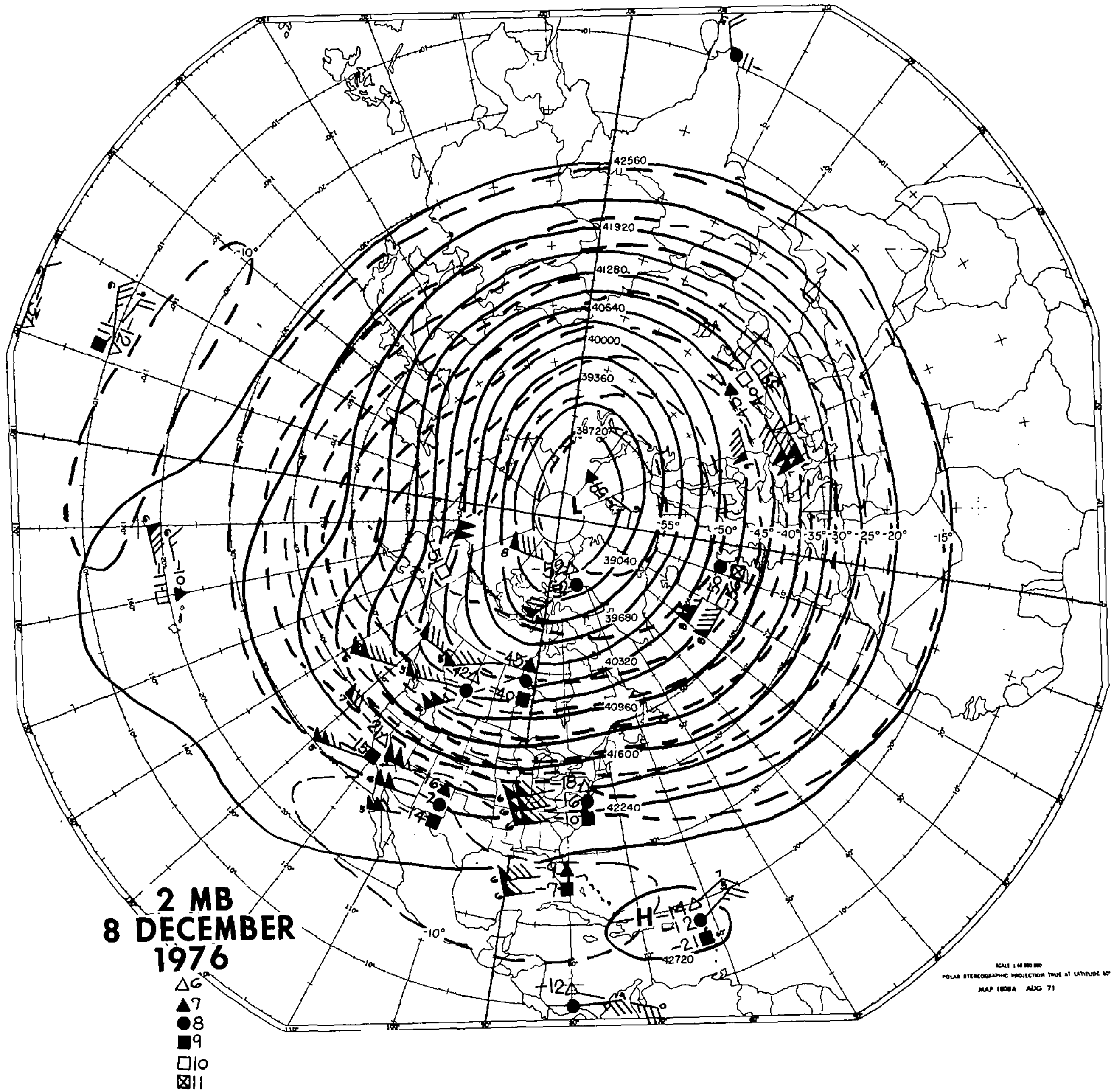
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L
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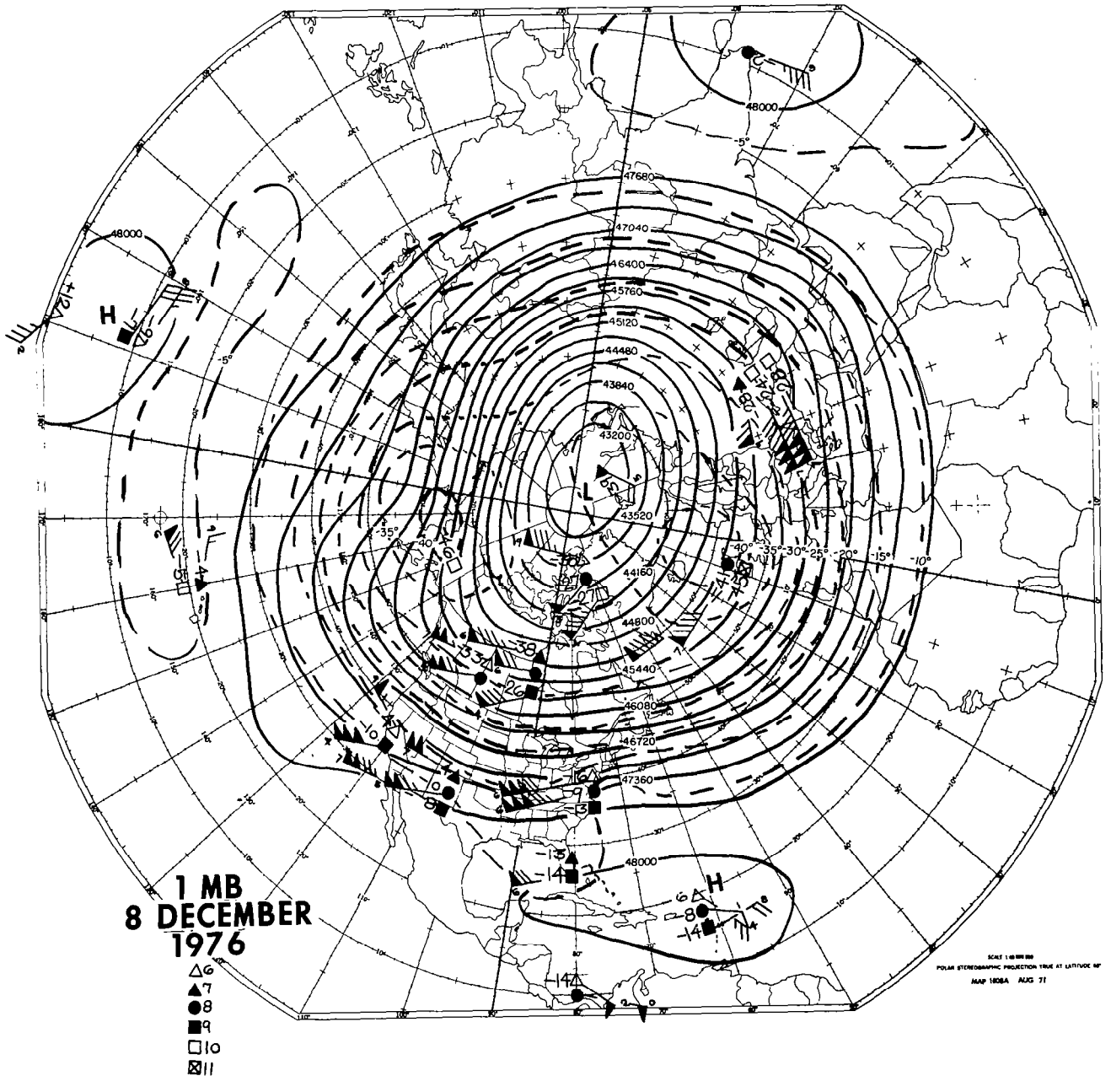
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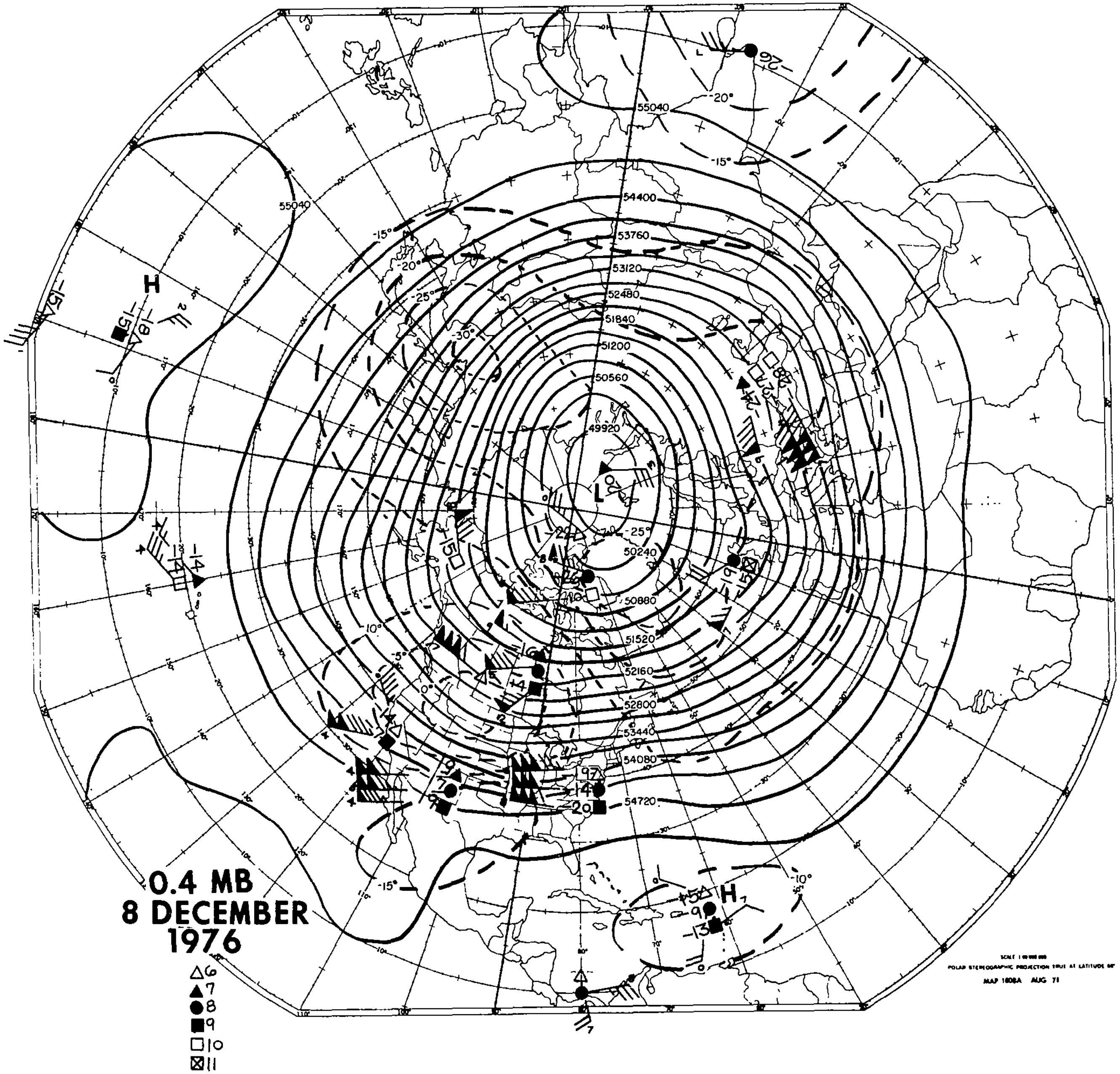
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1808A AUG 71



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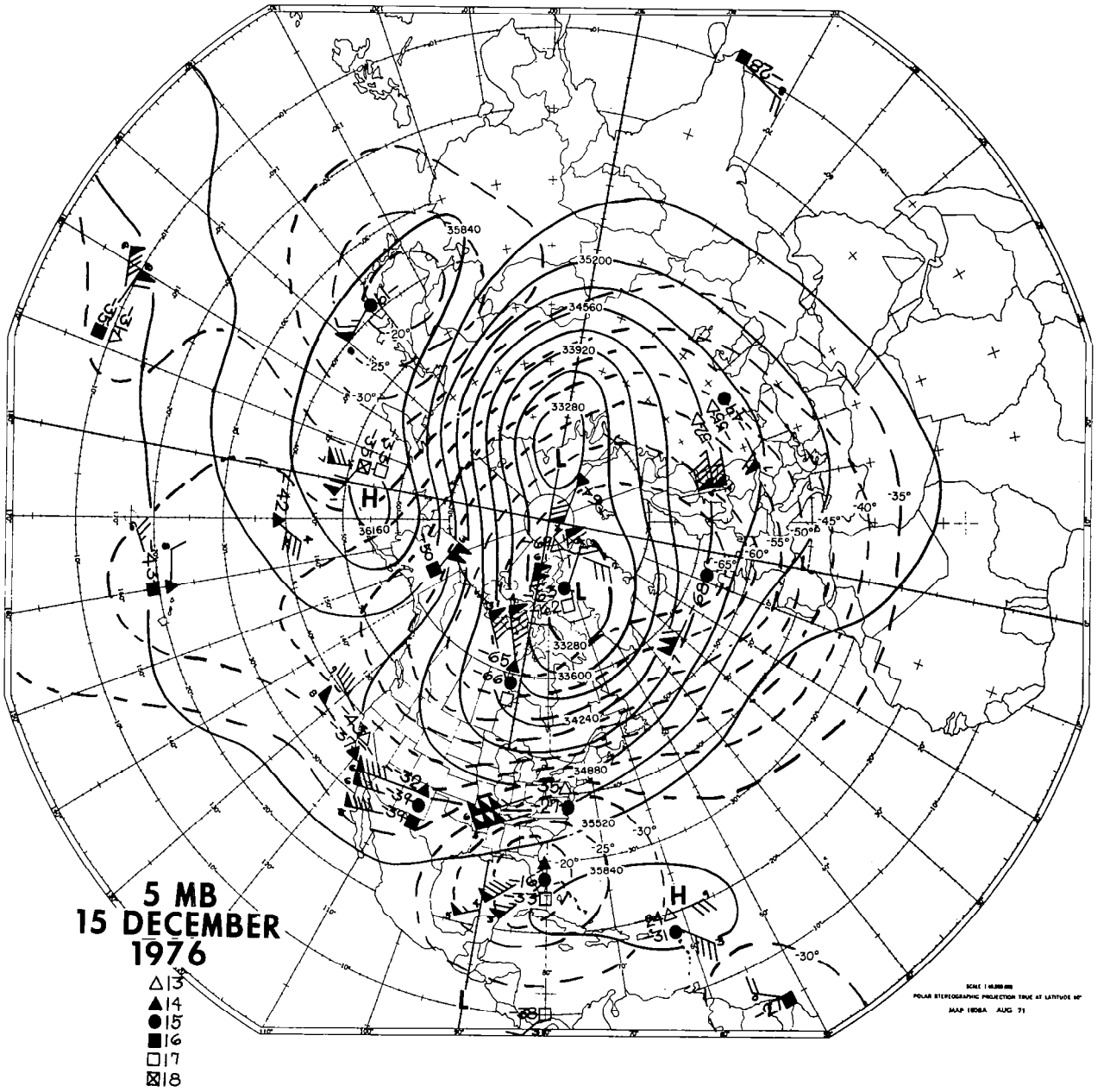
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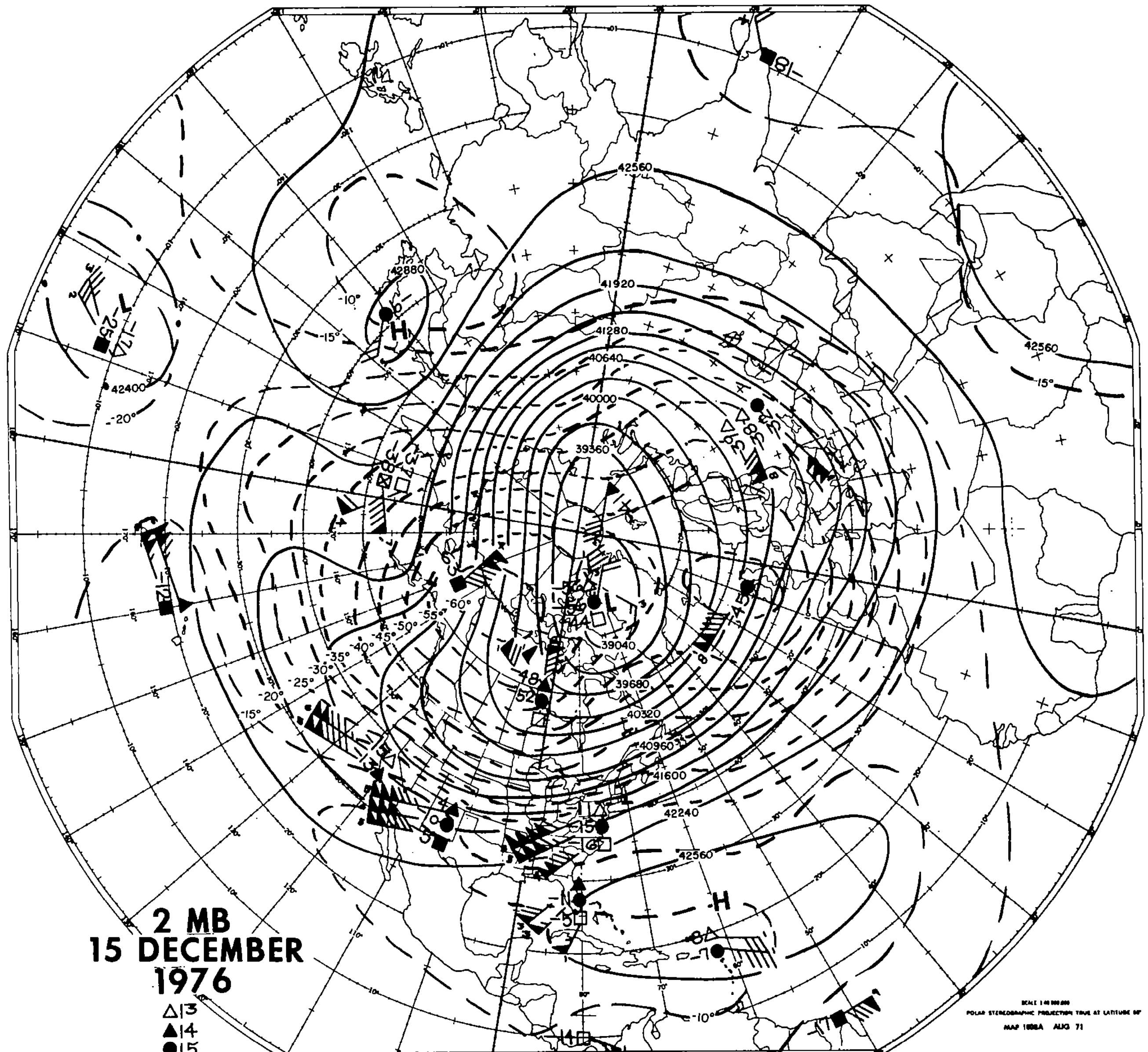

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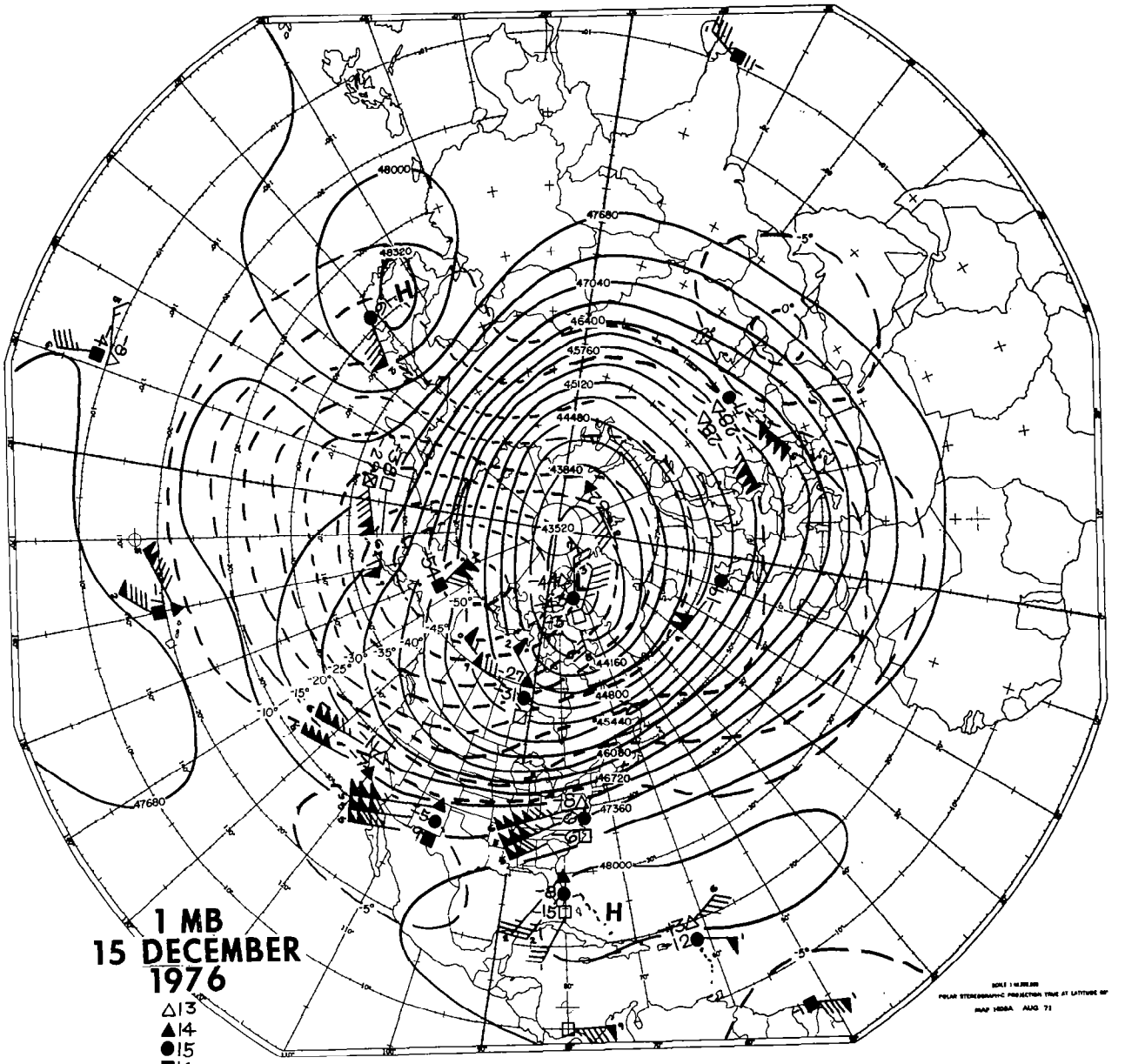
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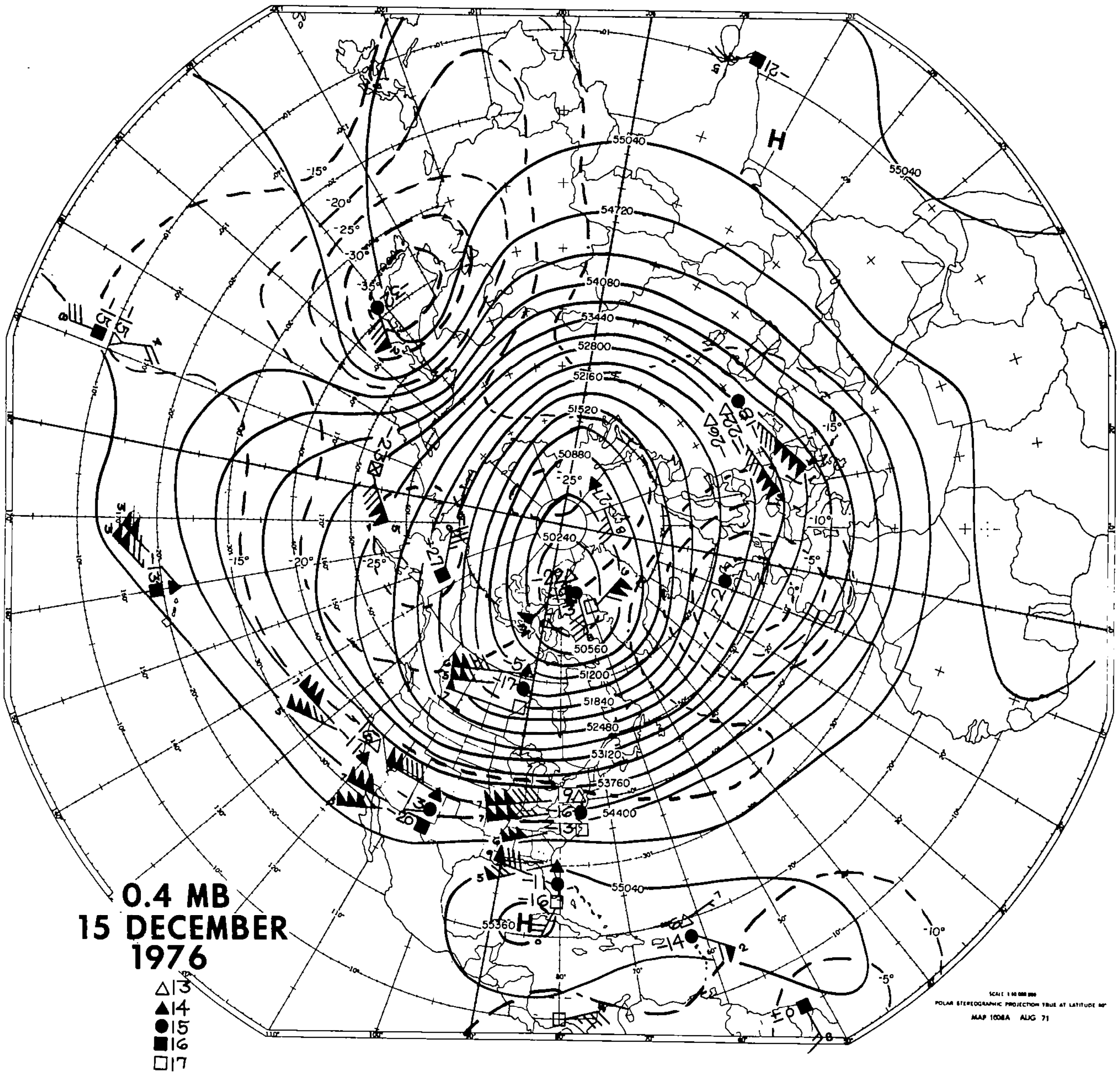

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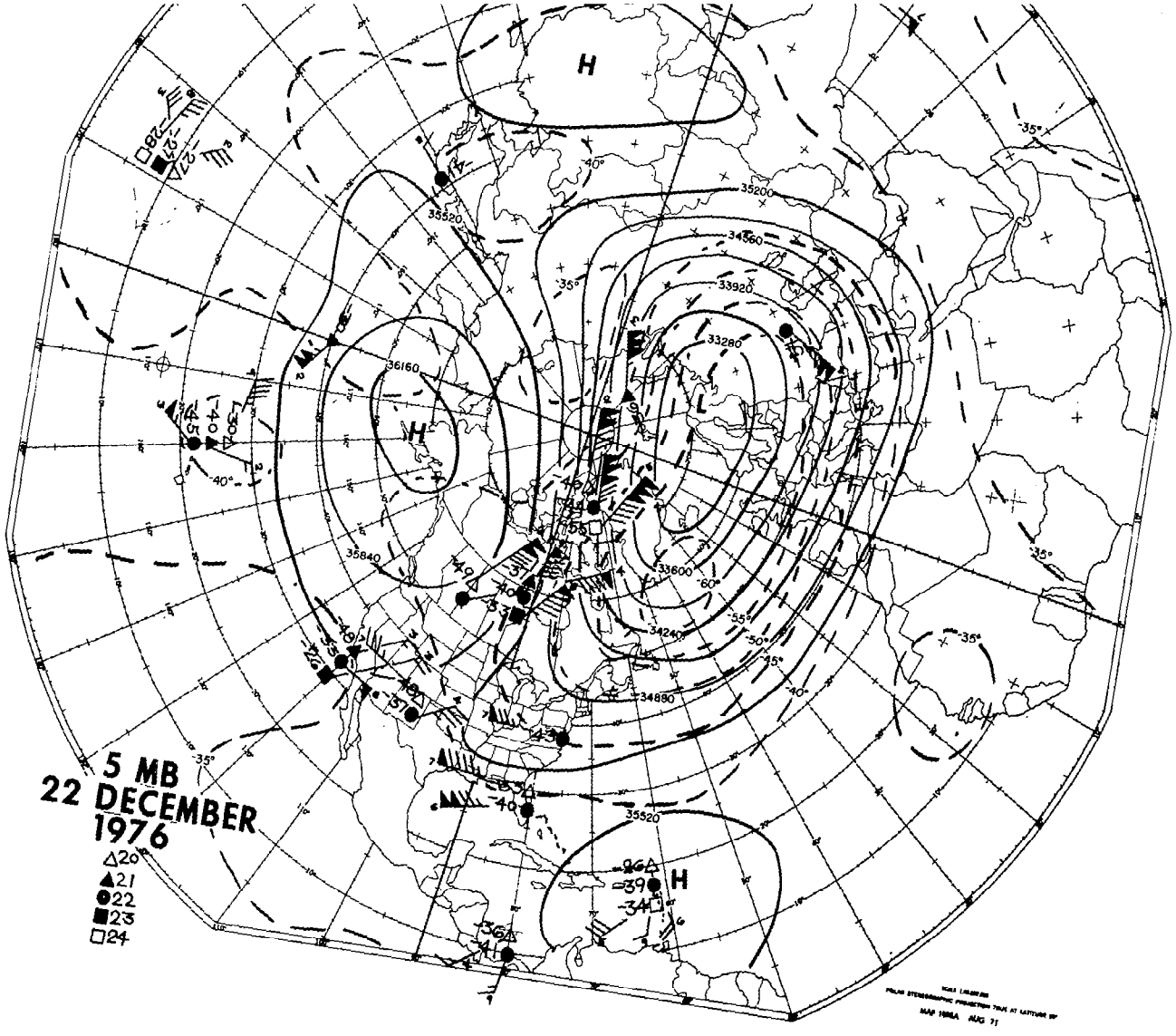
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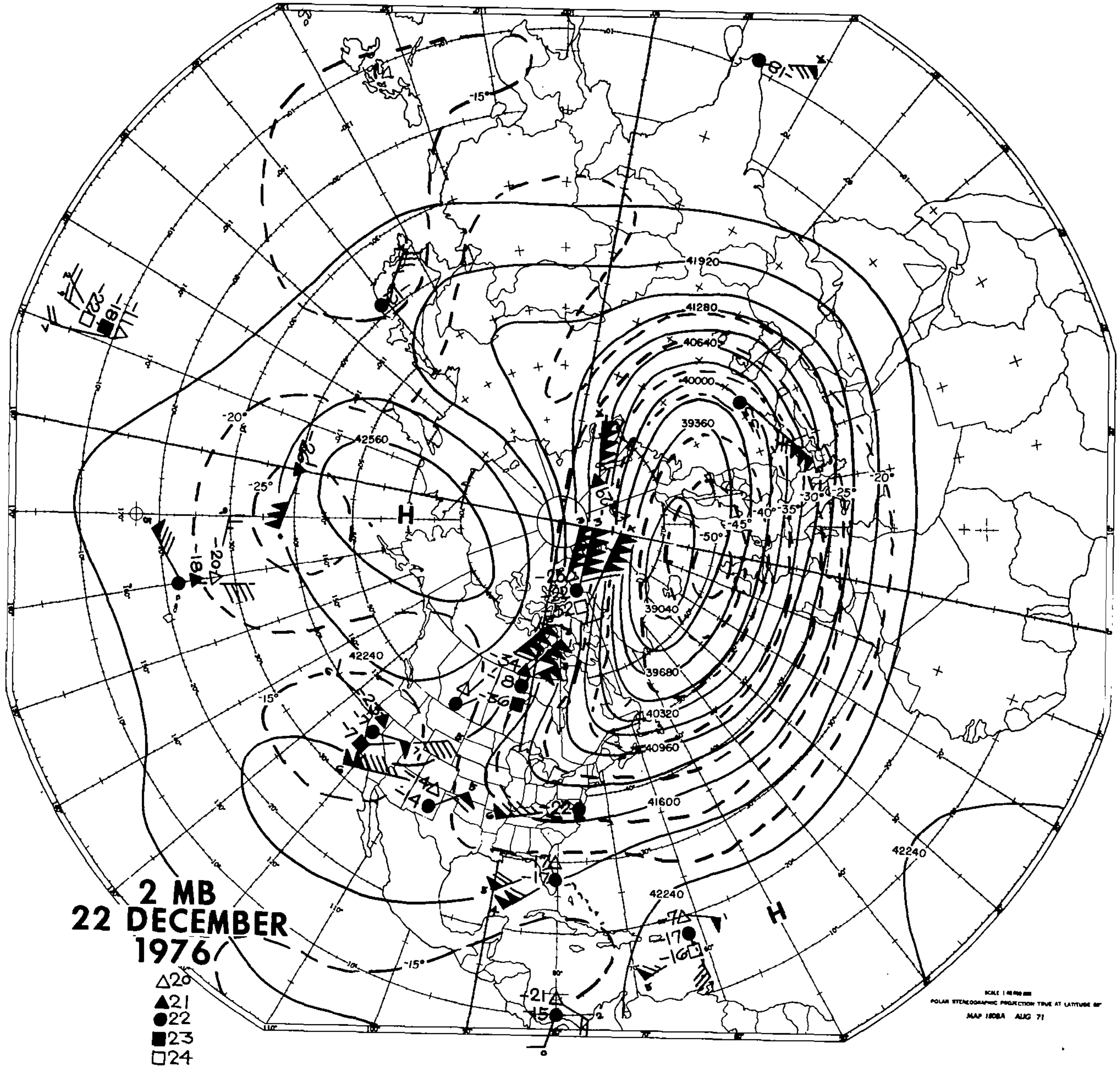
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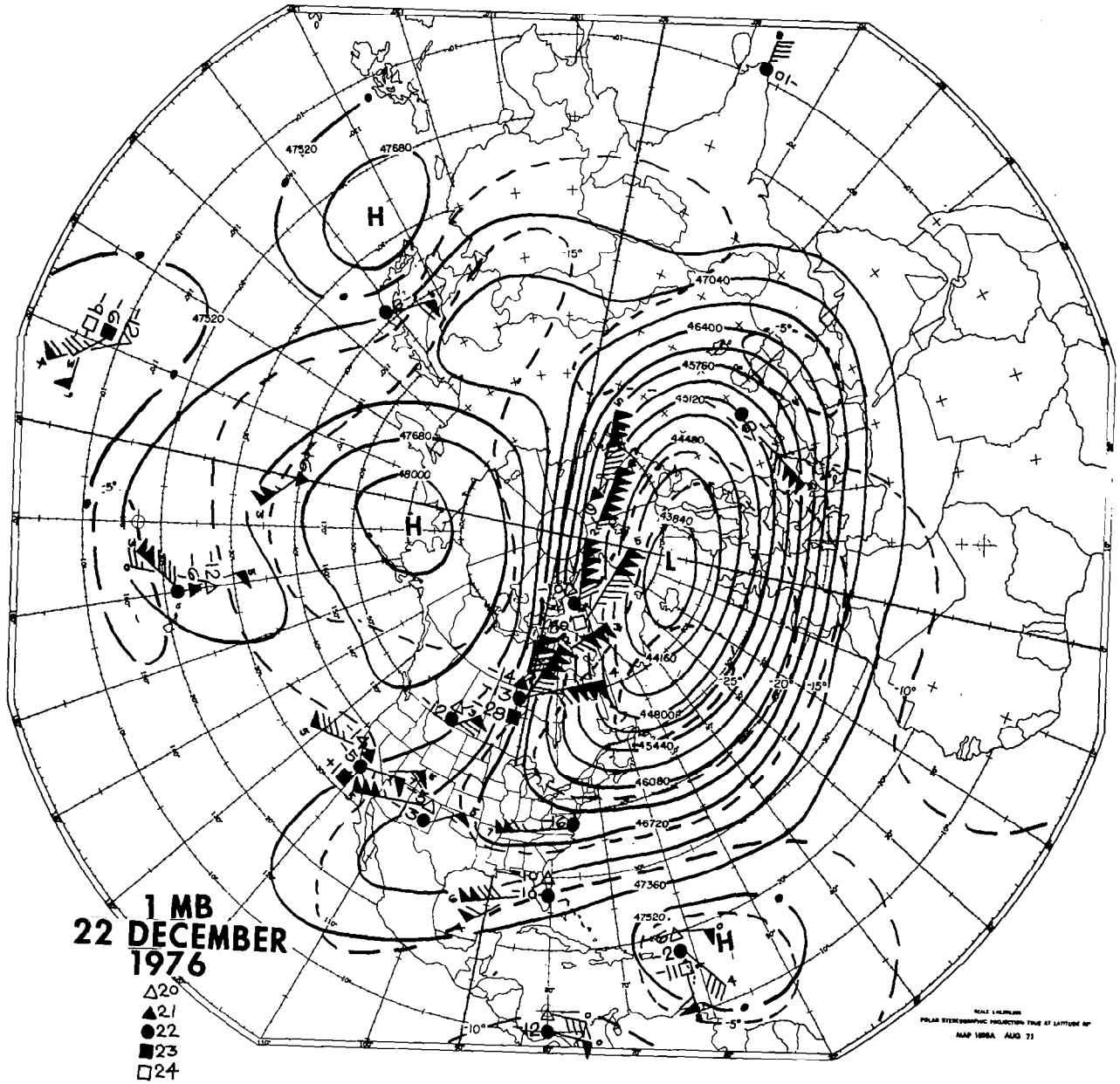
42560
H
-15°
-20°
-25°
-30°
-35°
-40°
-45°
-50°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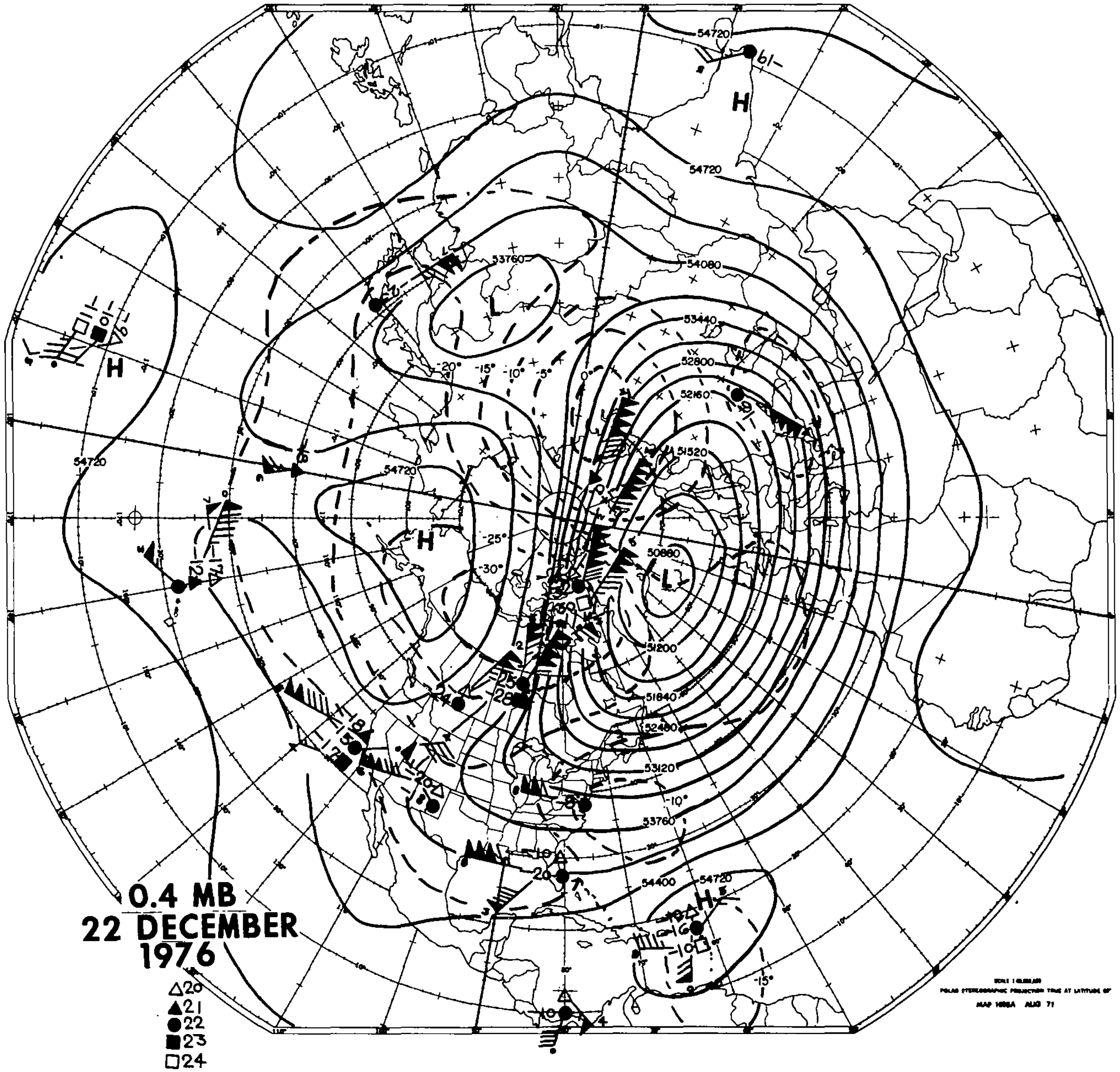
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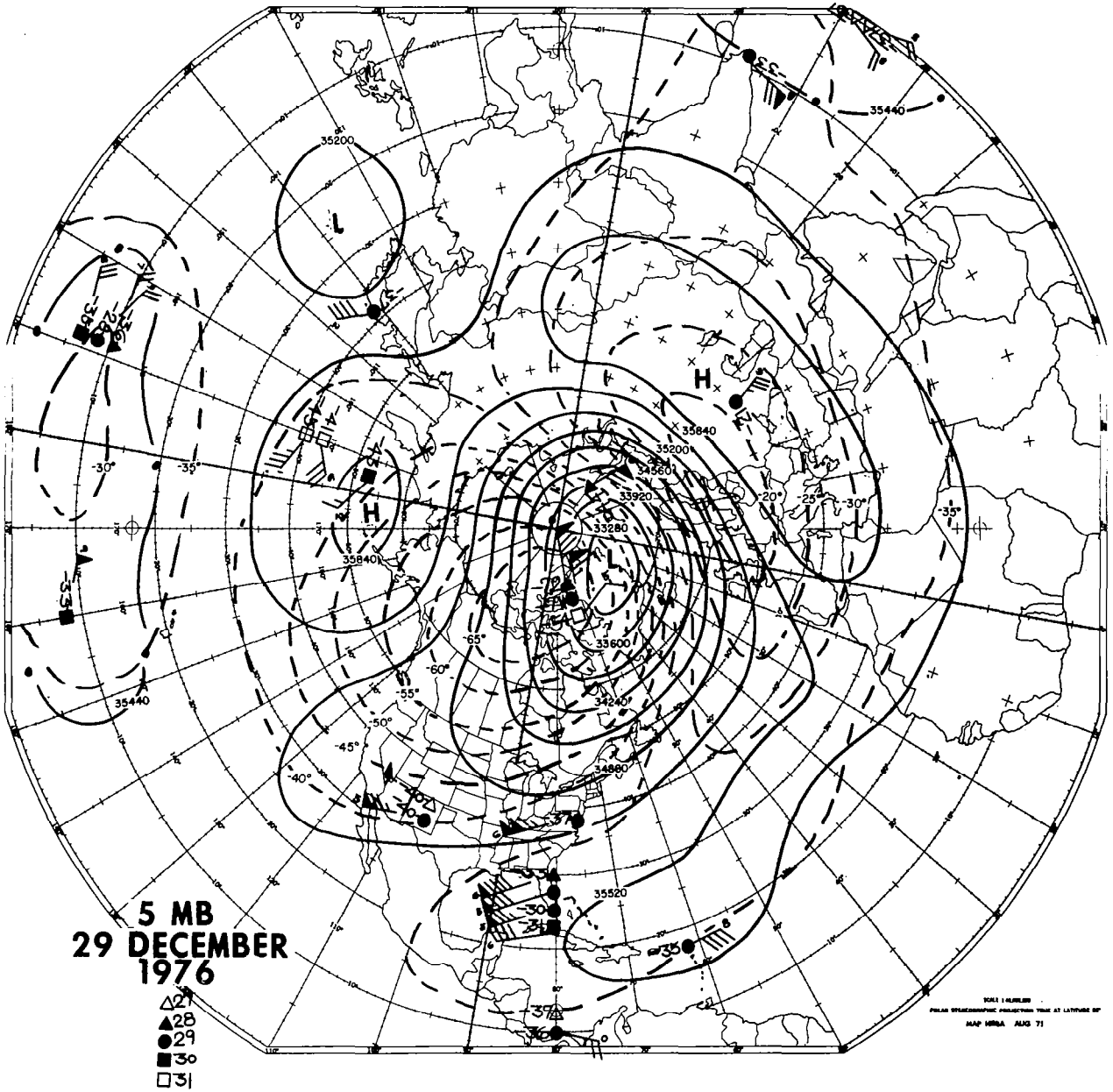
L
MAP 1106A AUG 71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29 DECEMBER
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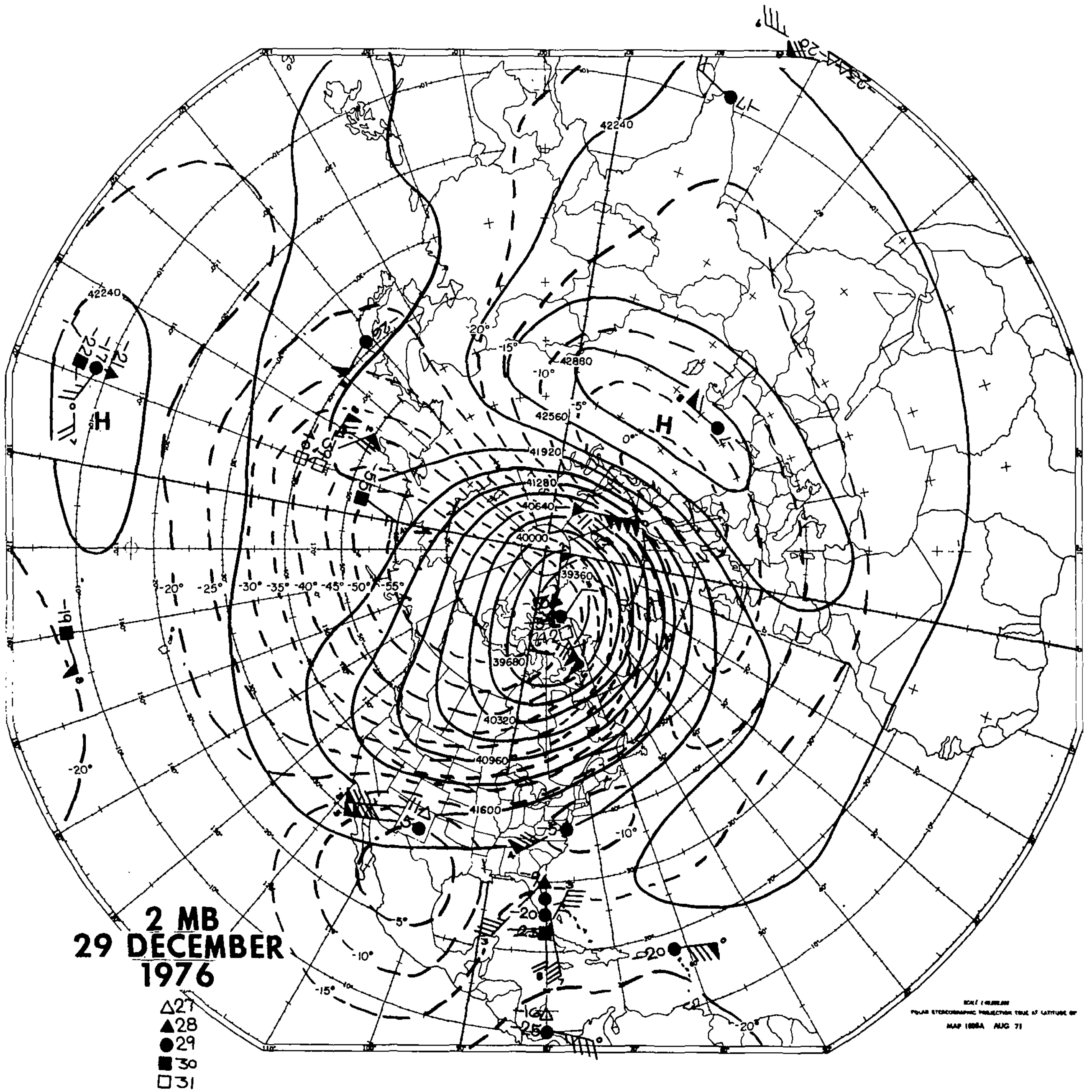
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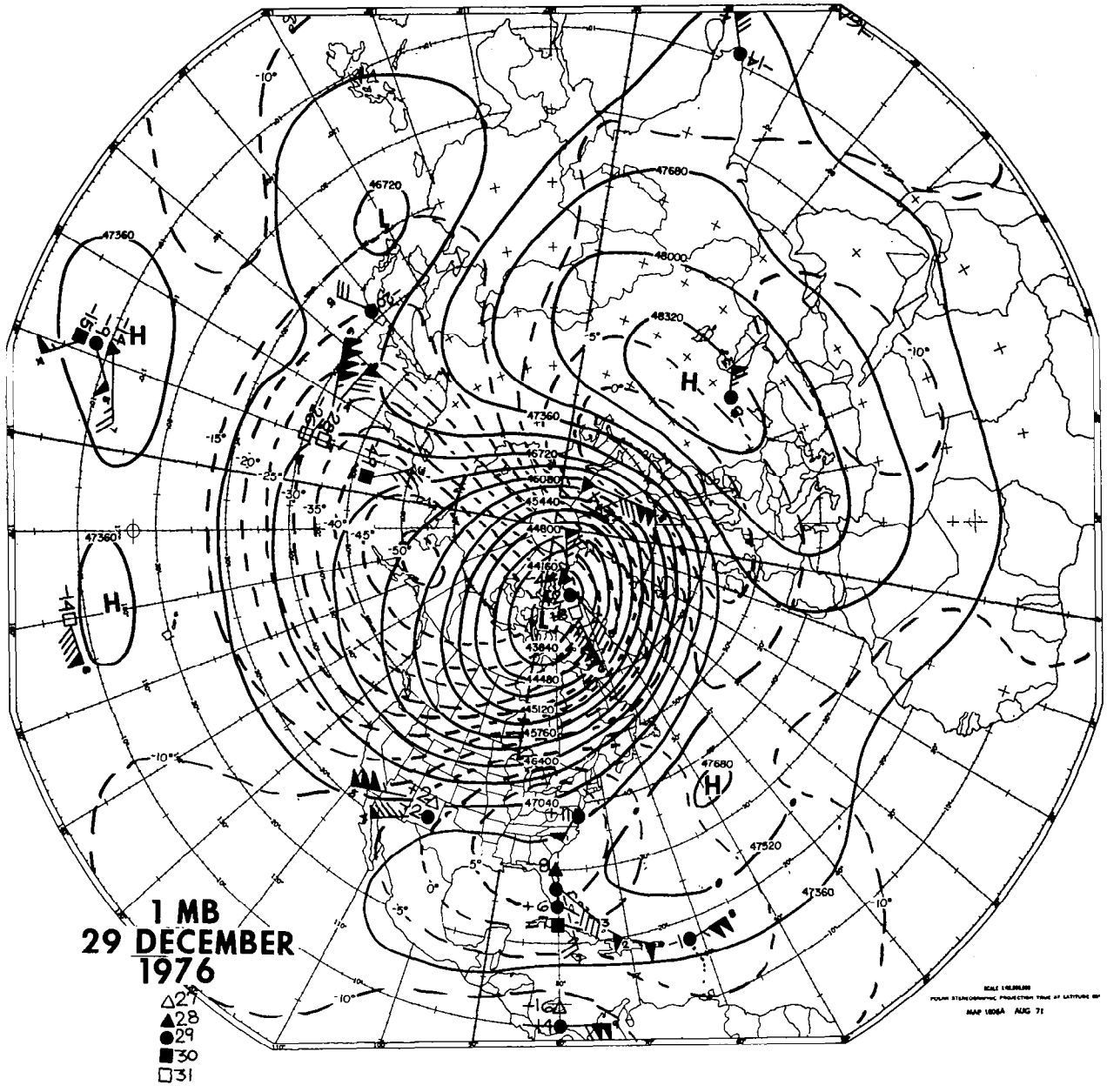
MAP 1086A AUG 71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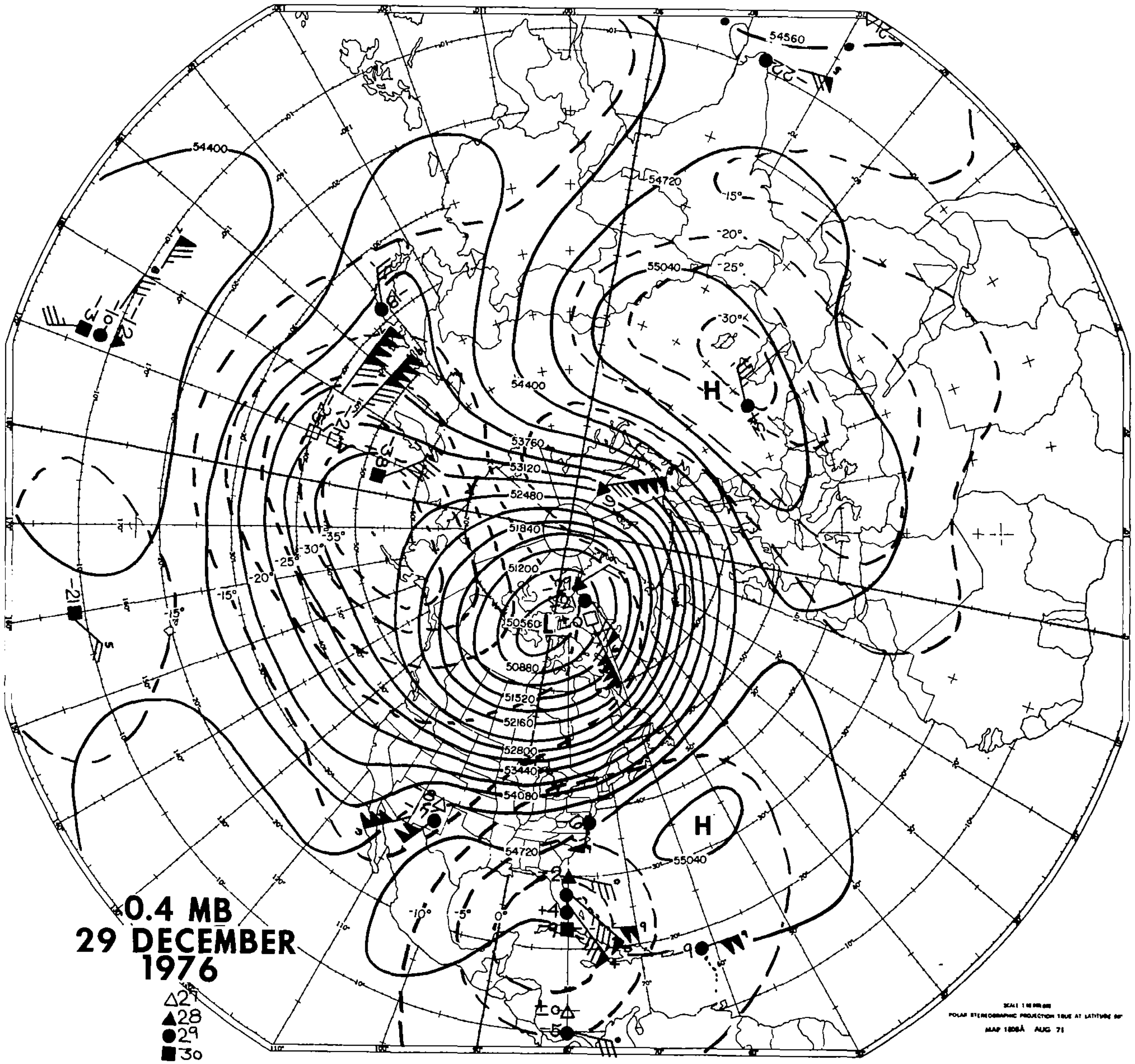

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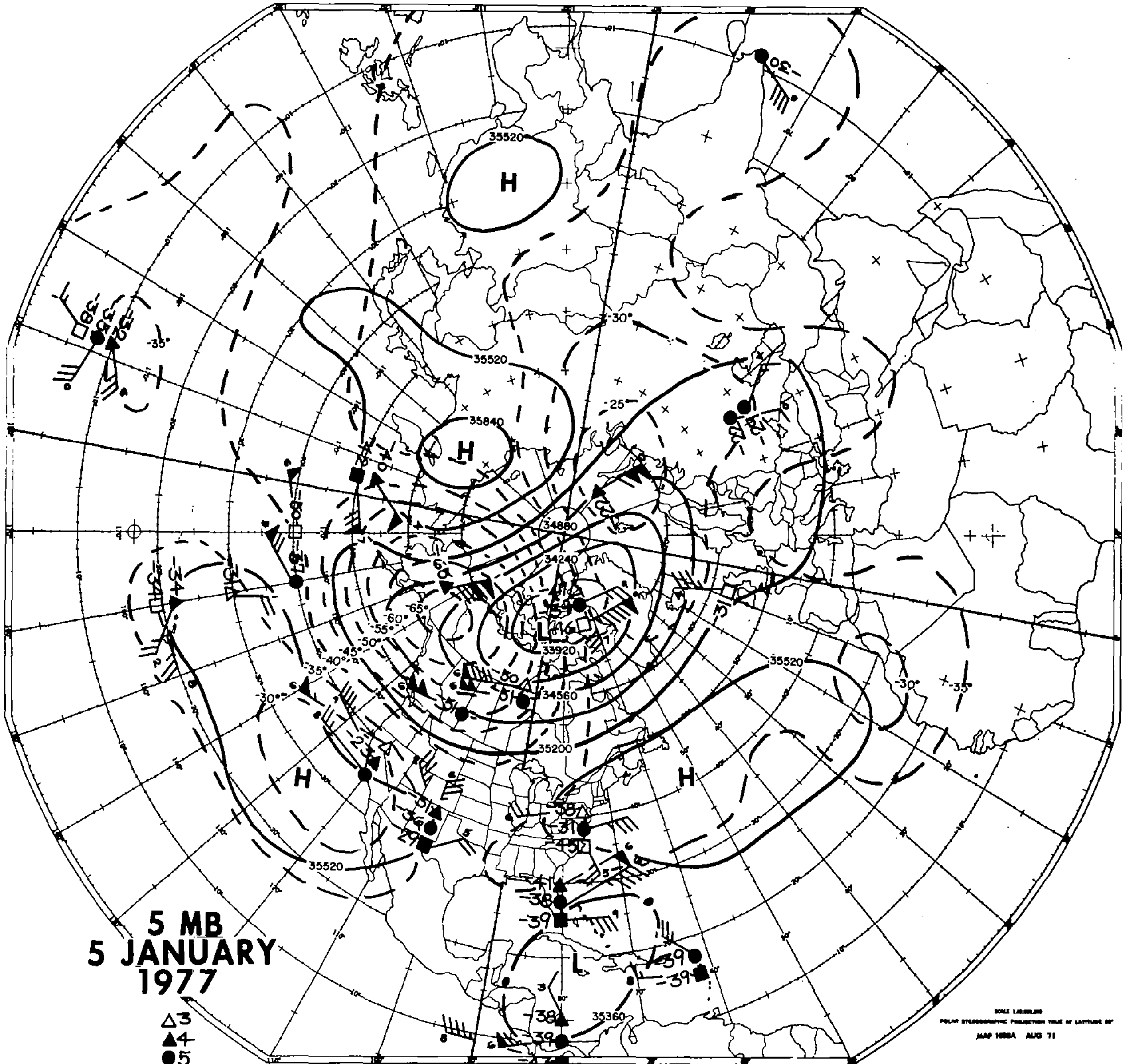

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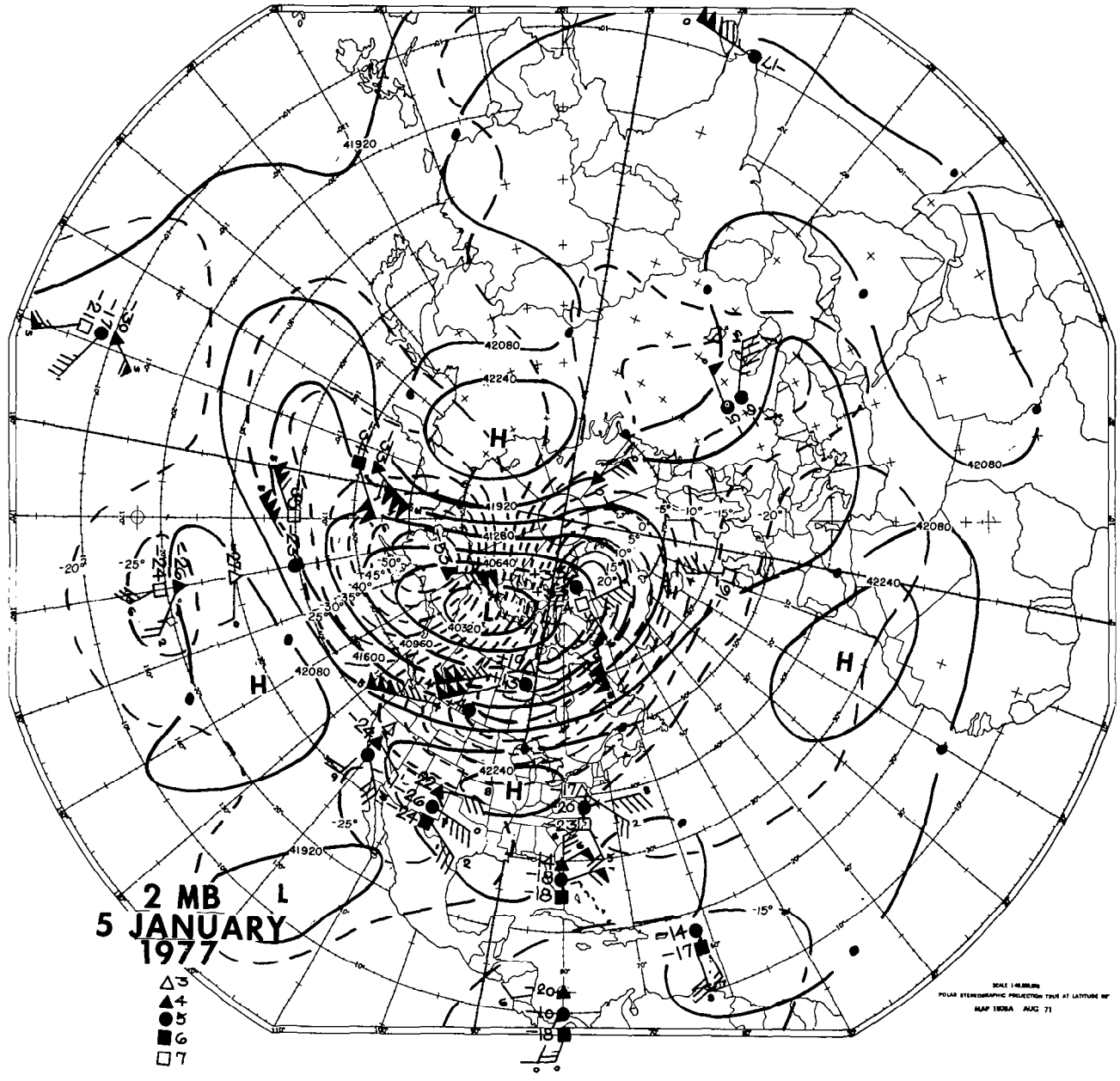
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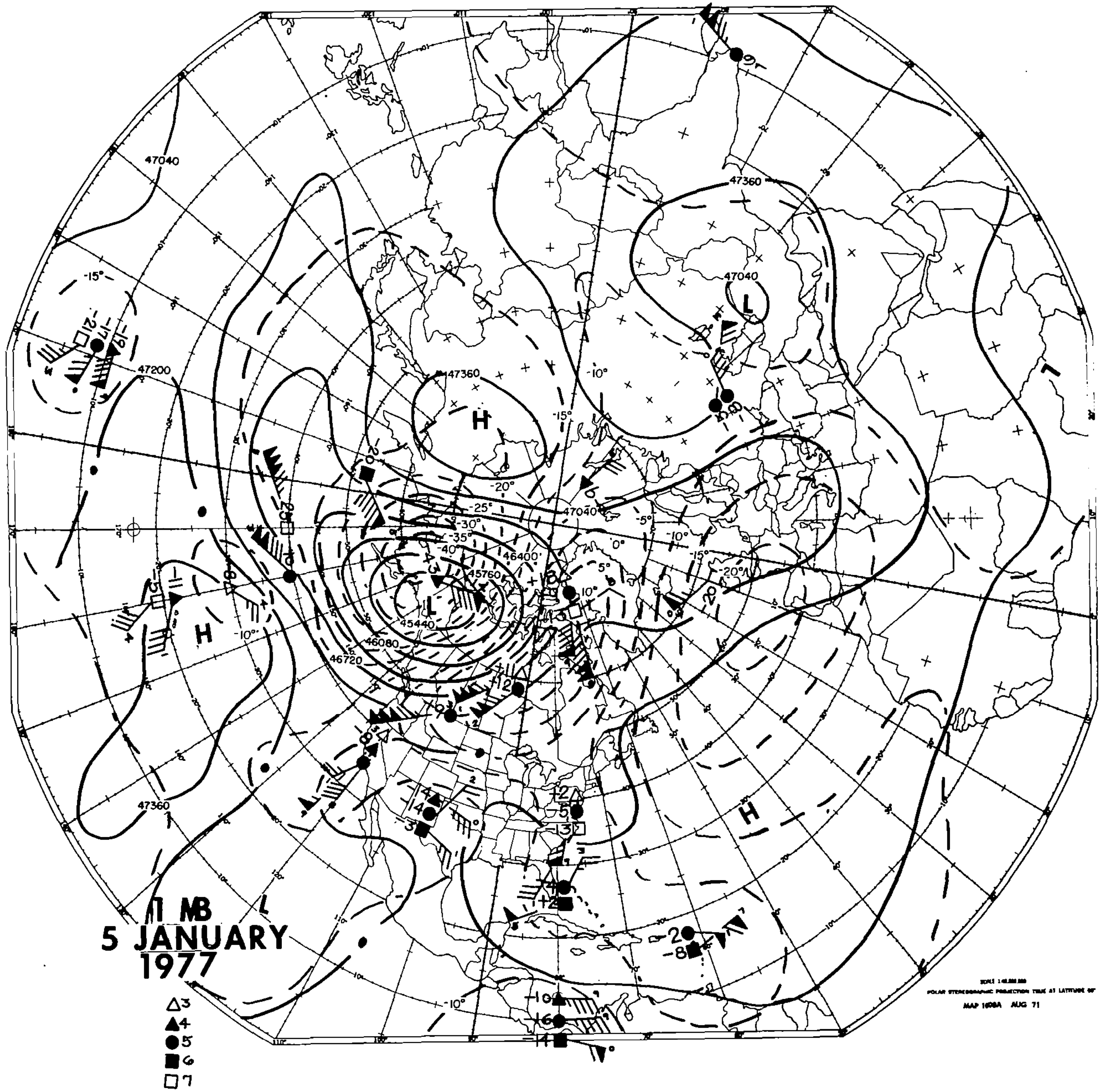
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1606A AUG 71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△3
▲4
●5
■6
□7
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46400
45760
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L
-10°
-15°
-20°
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-30°
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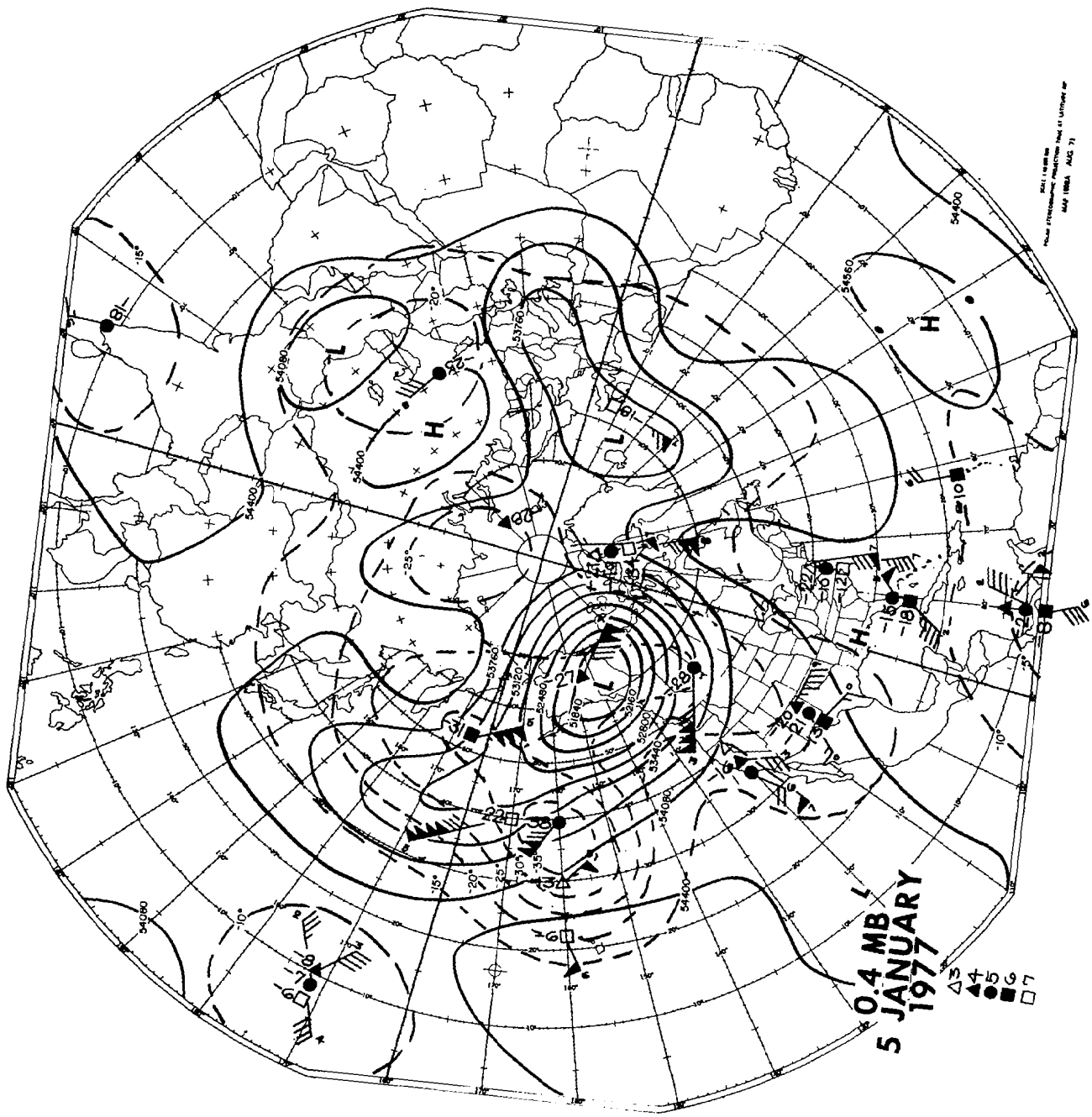
-40°
MAP 1608A AUG 71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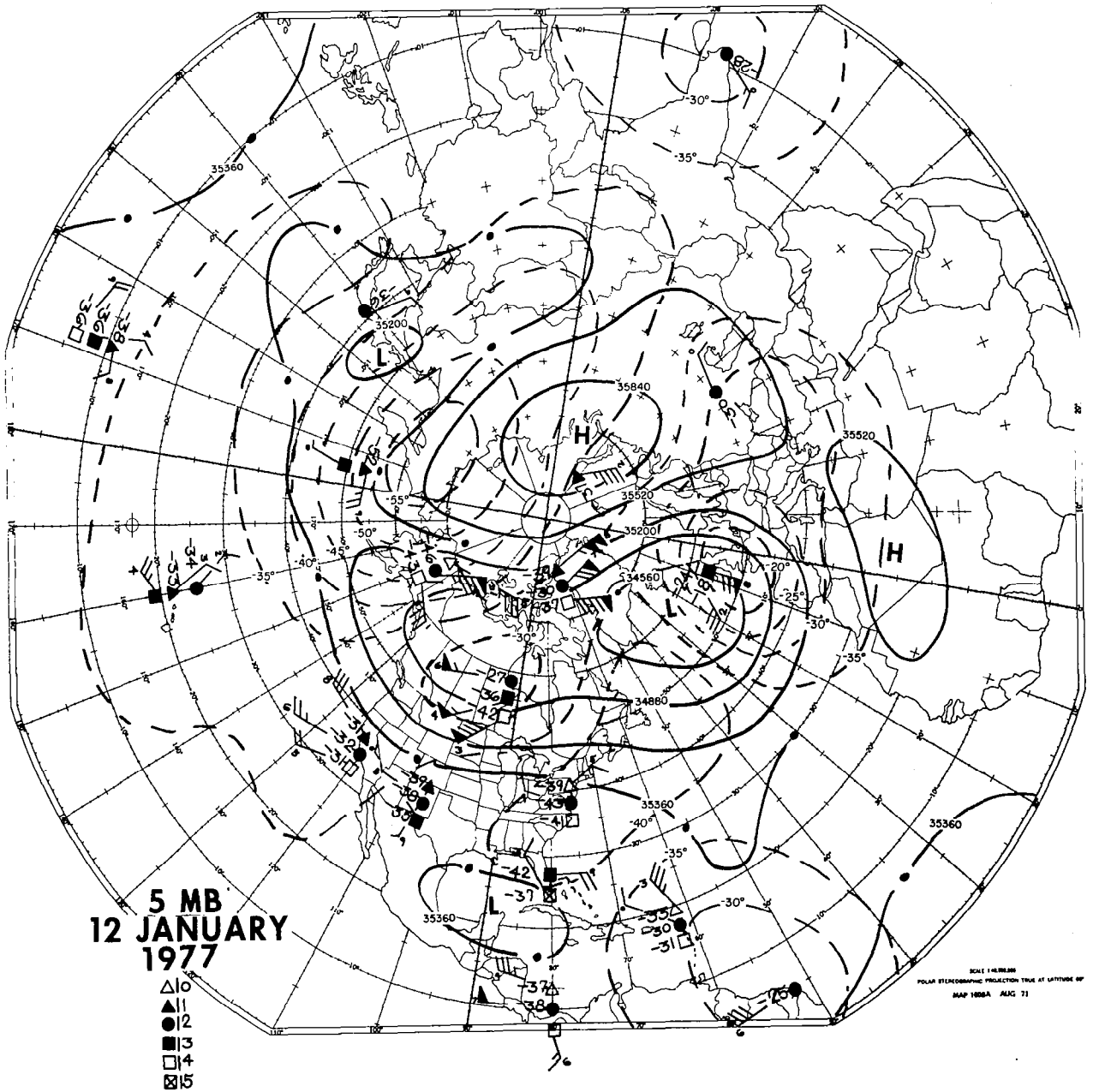
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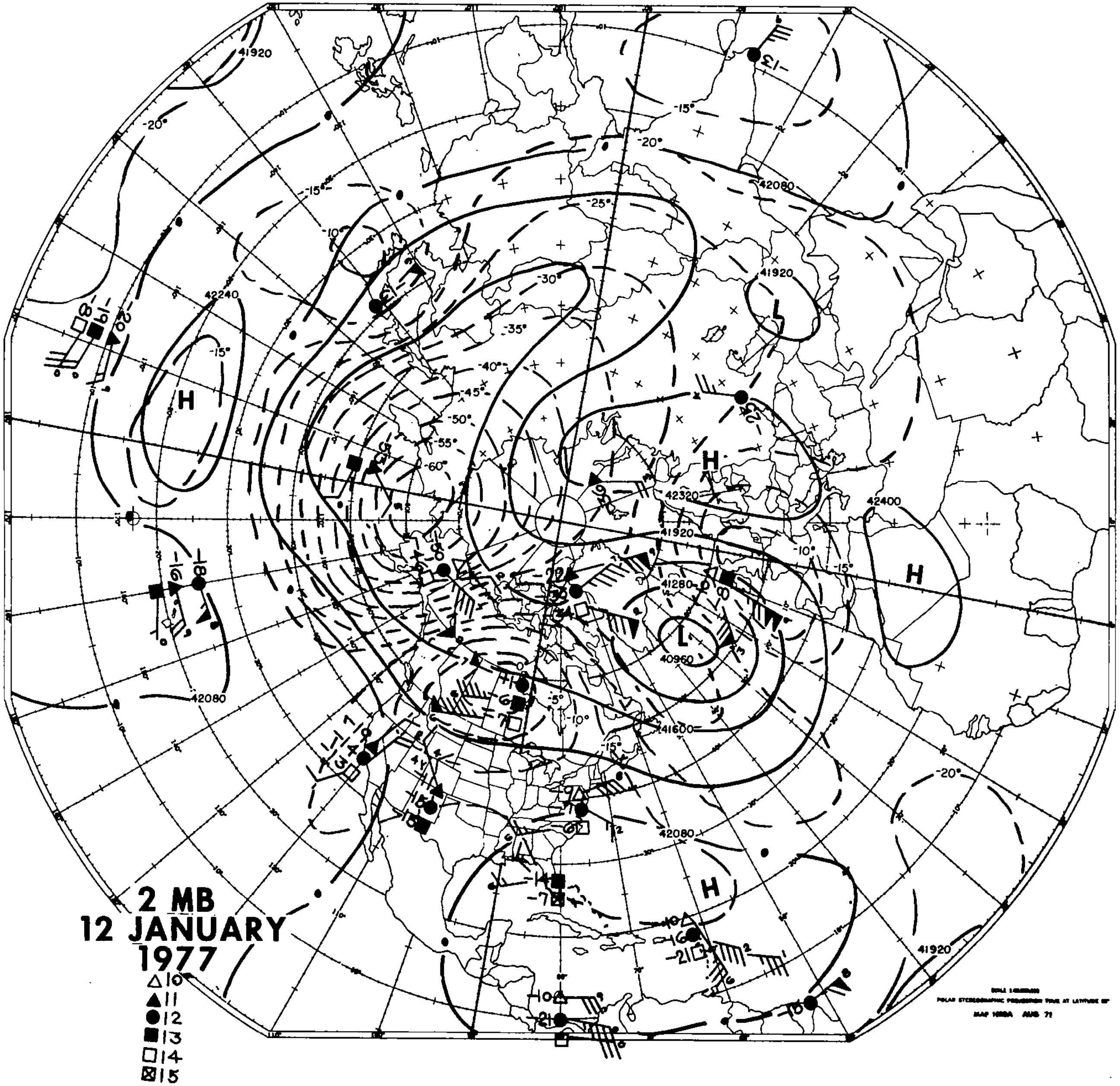

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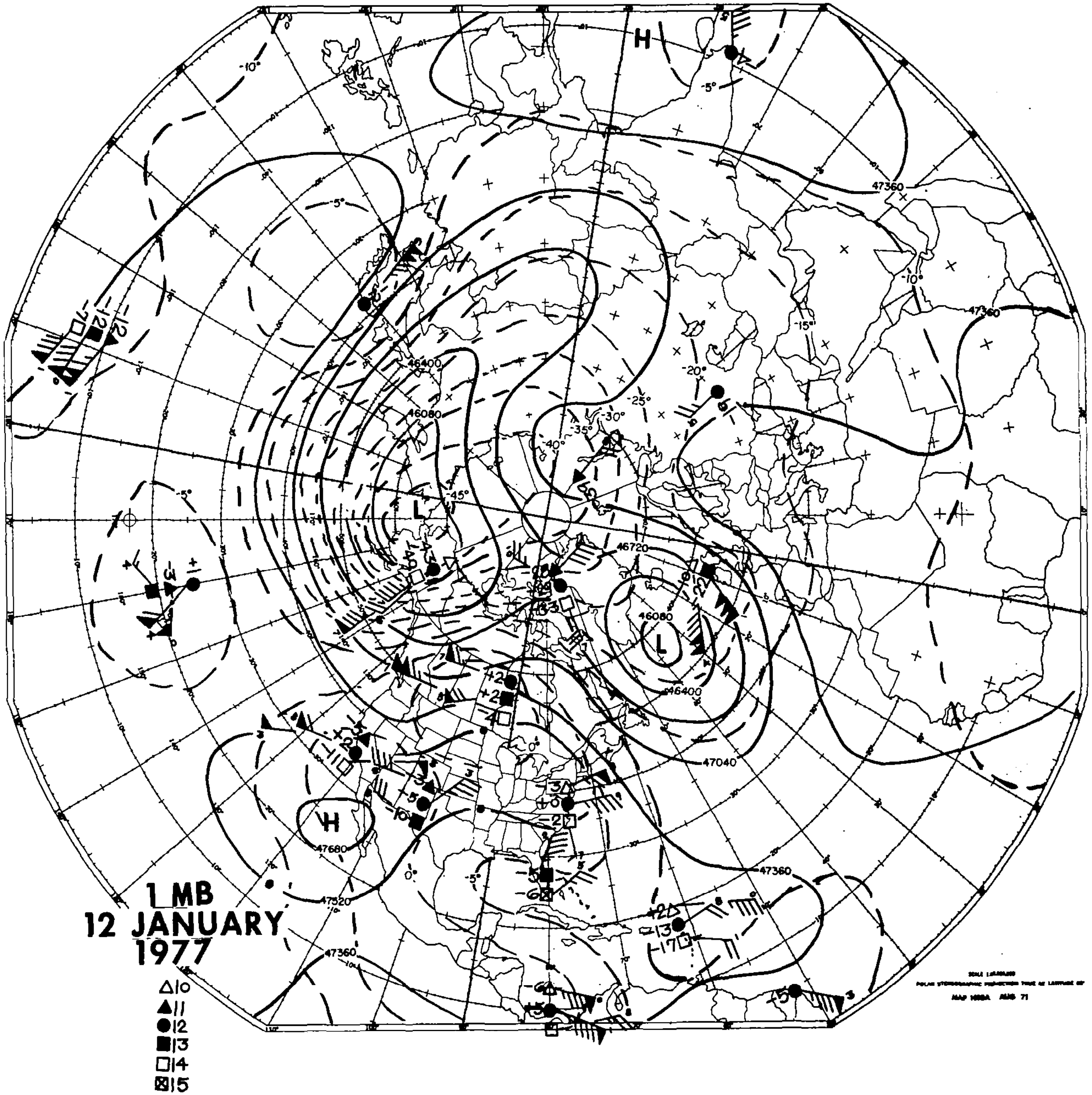
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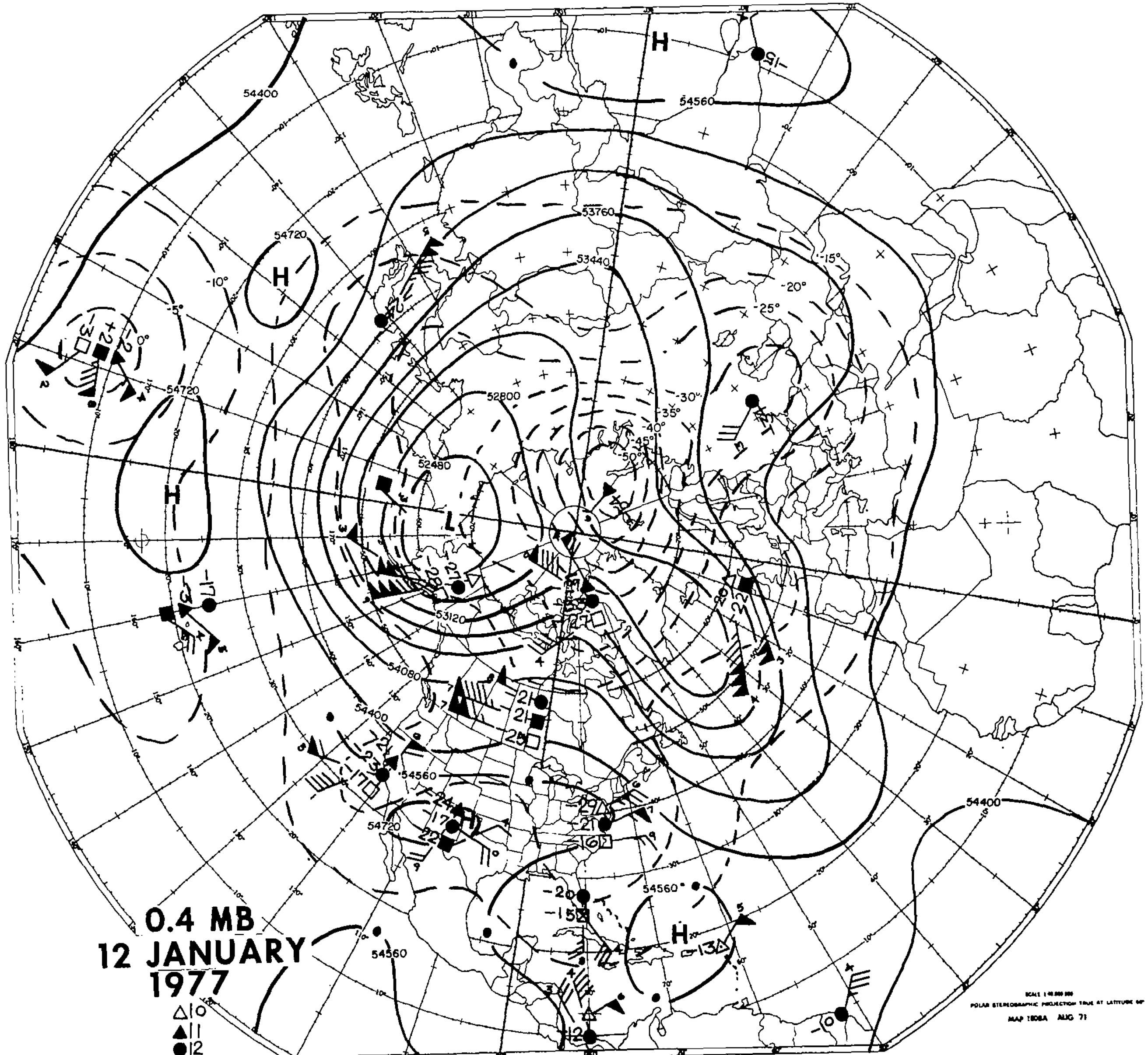

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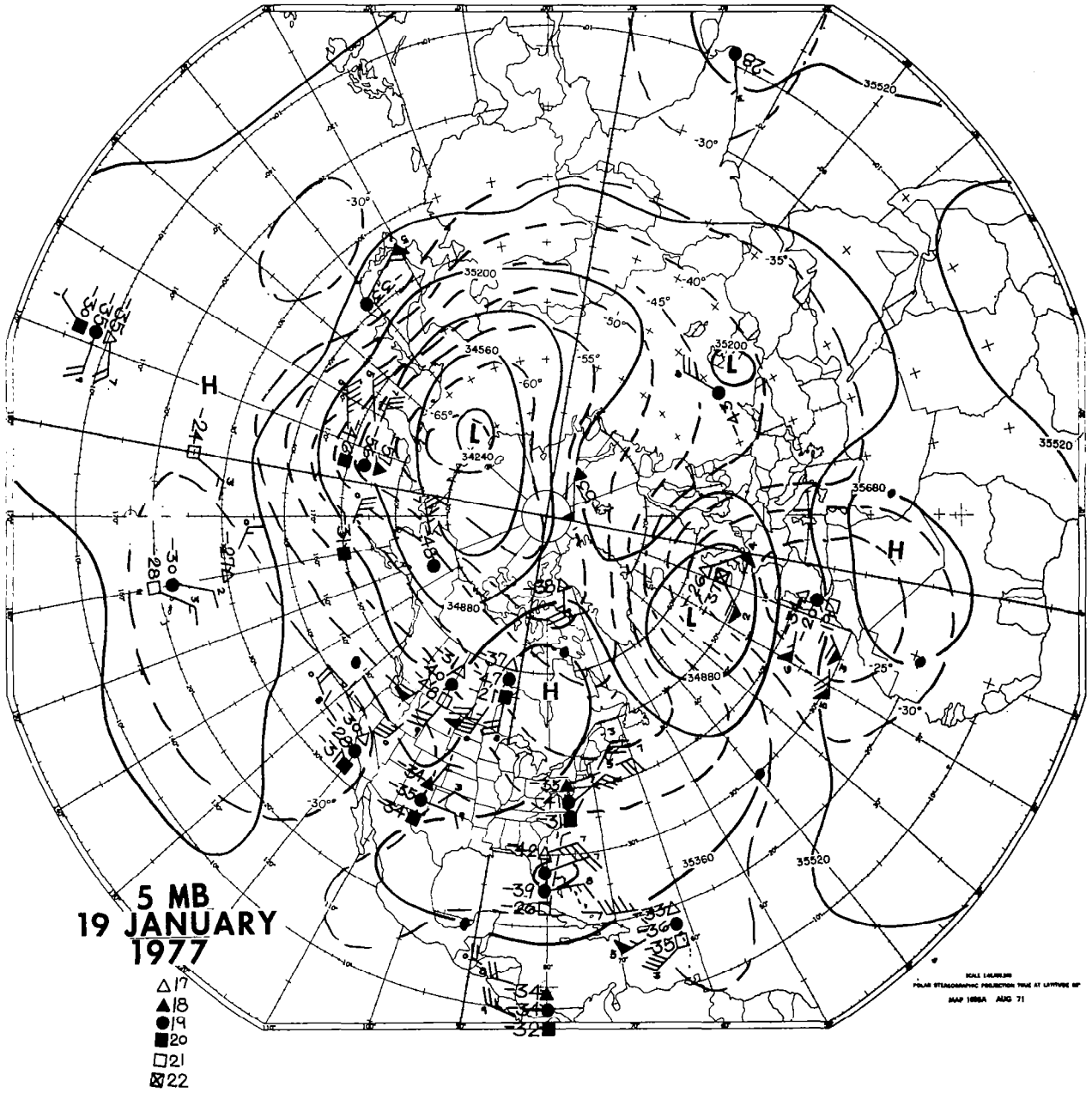
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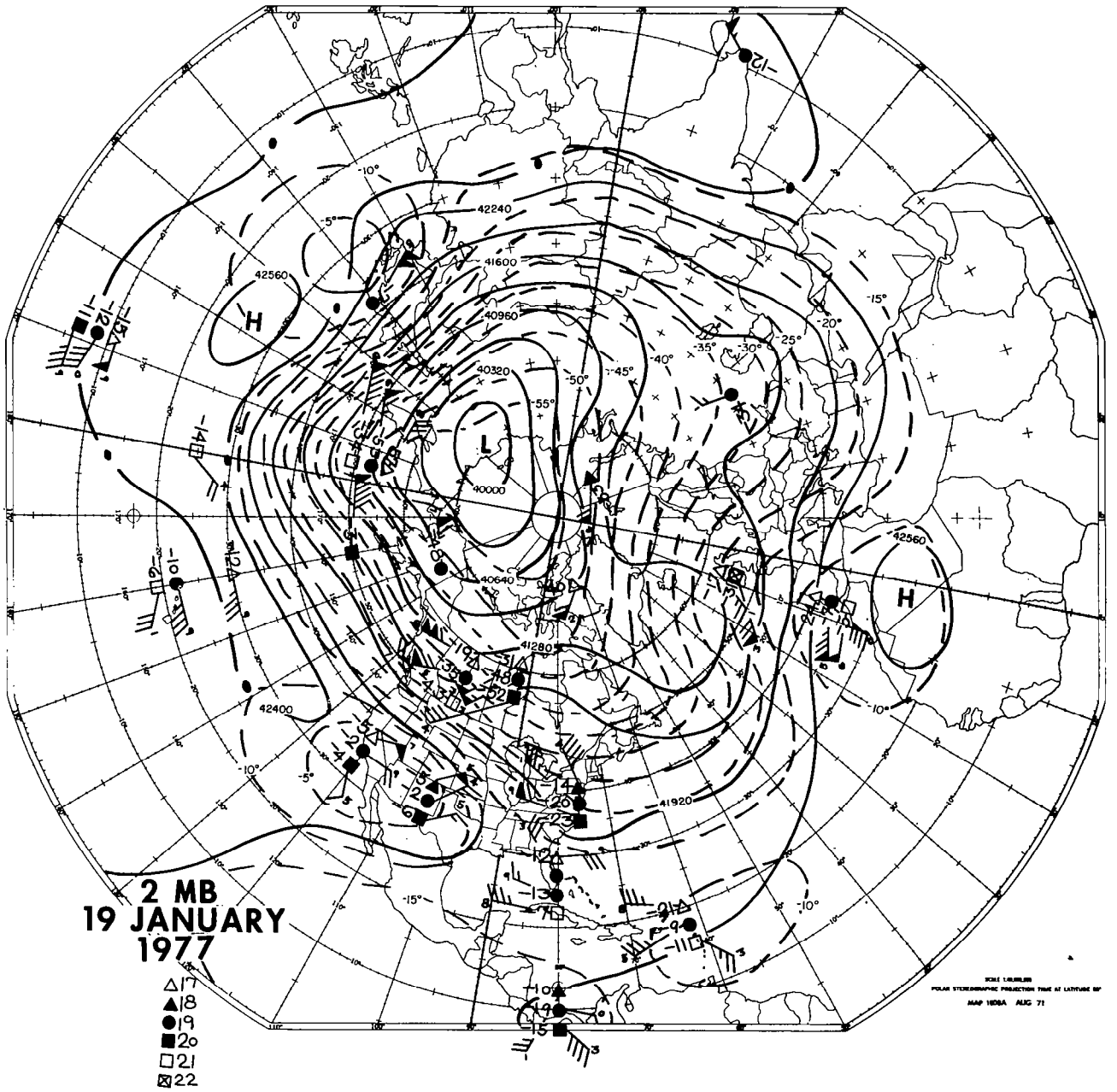
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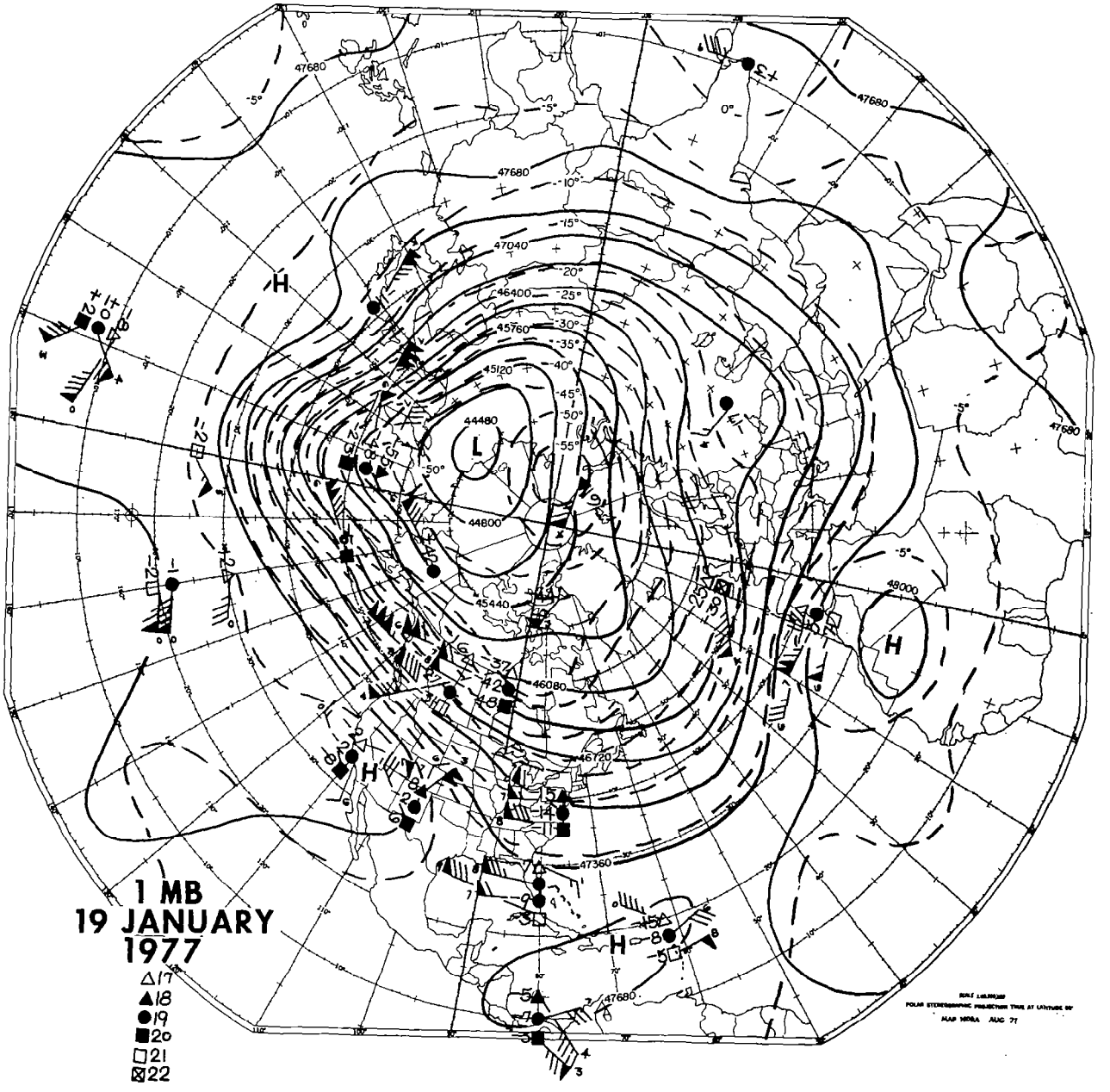
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1608A AUG 71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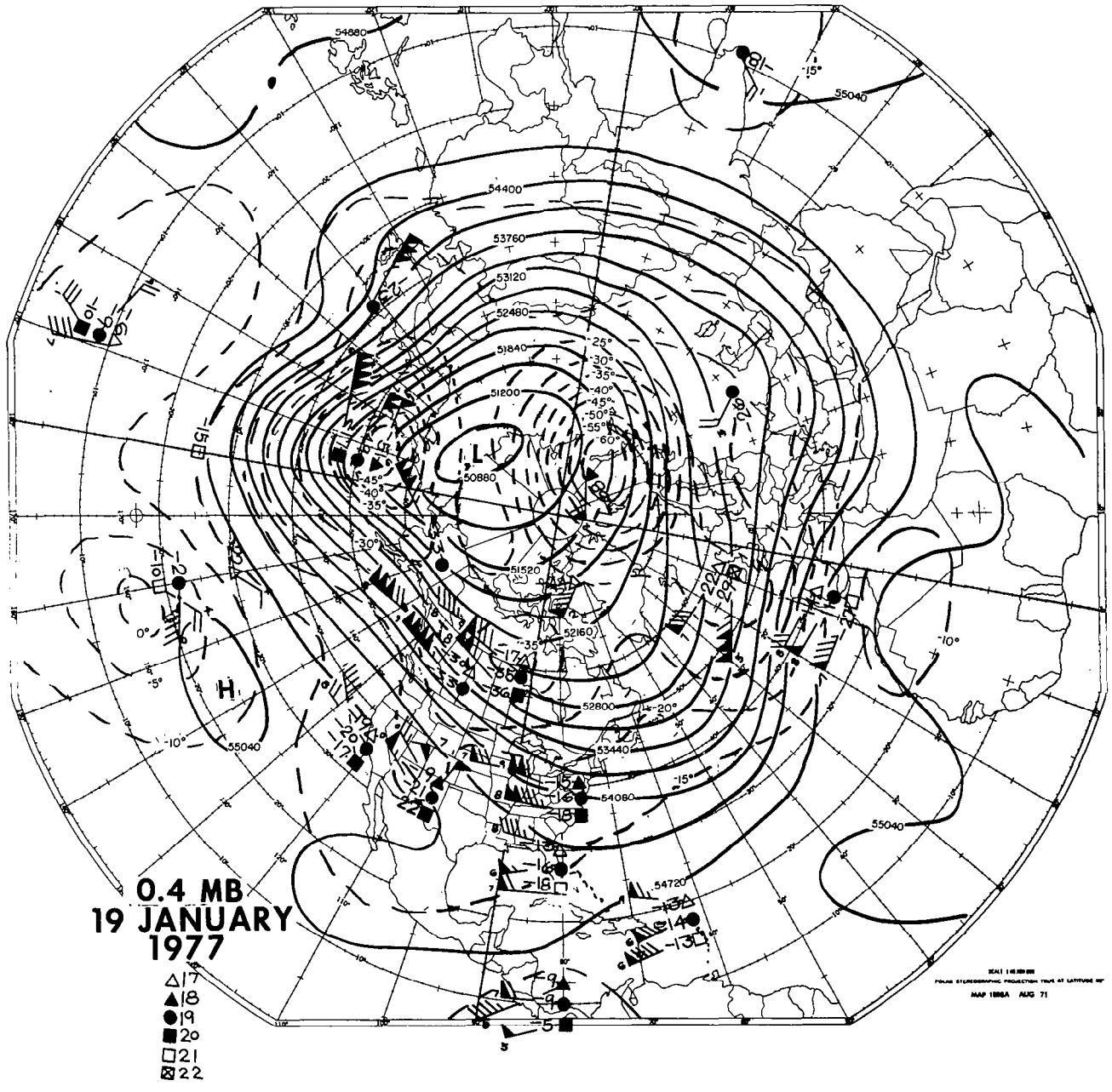
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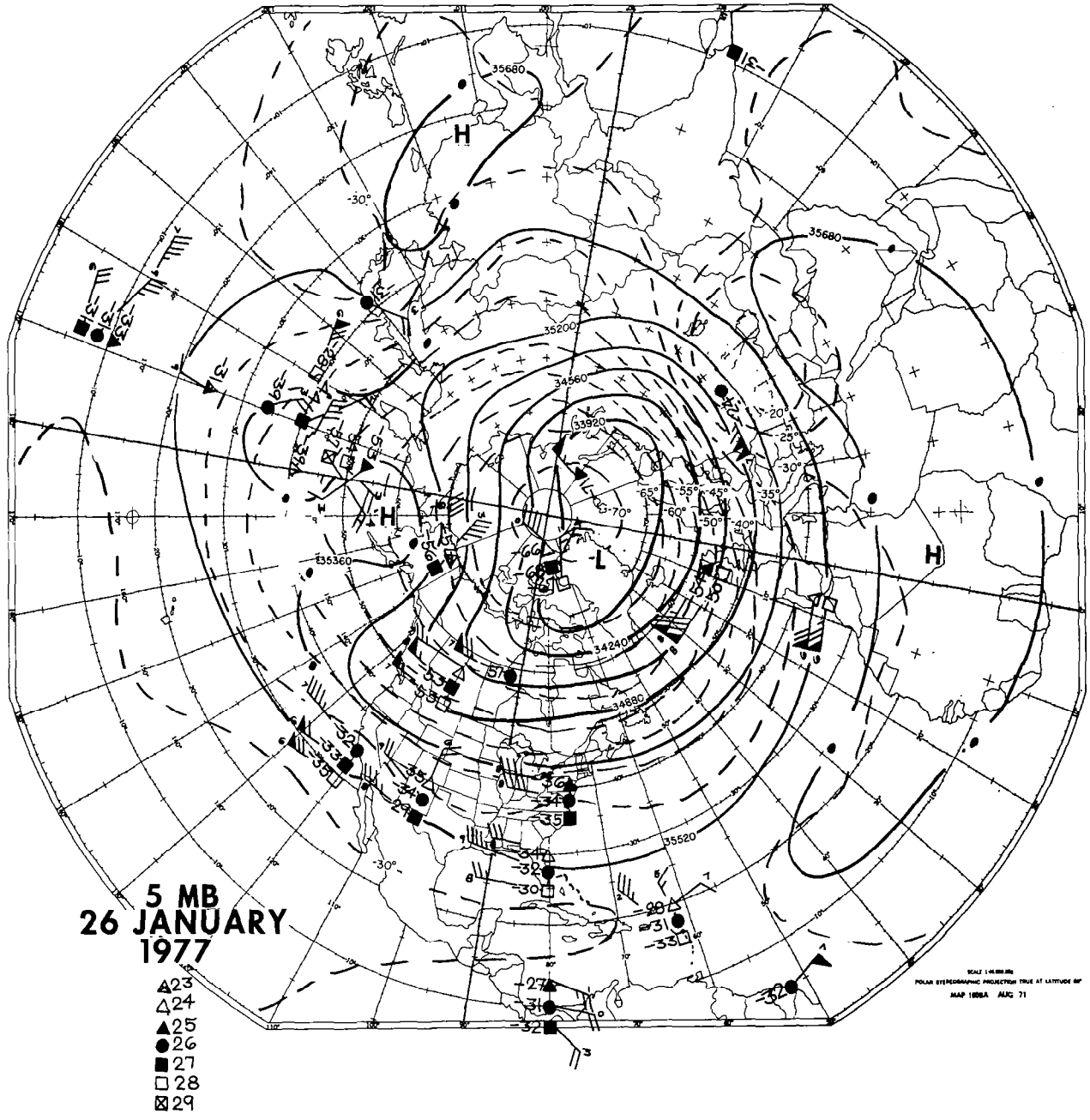
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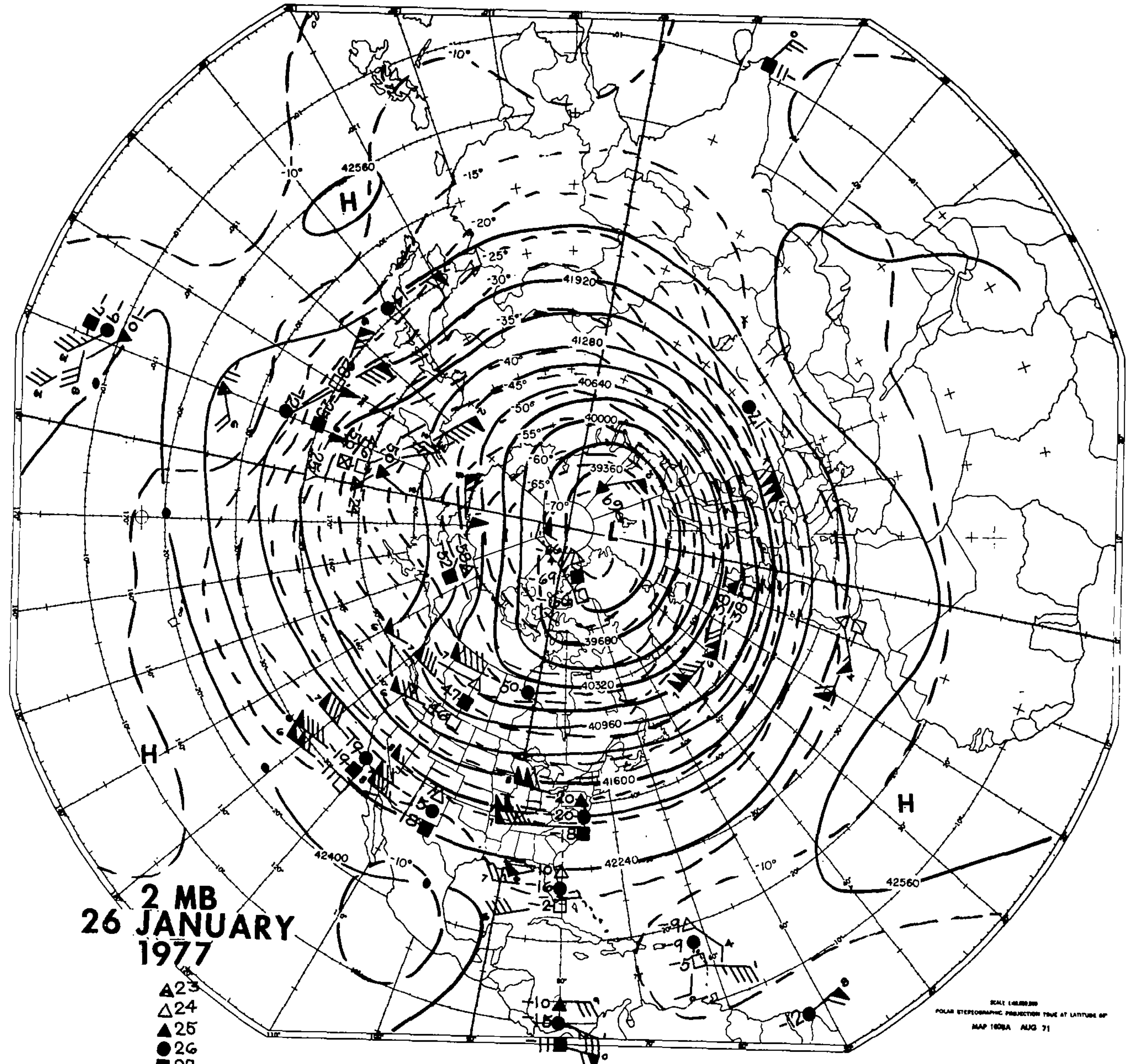
-70°
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1008A AUG 71



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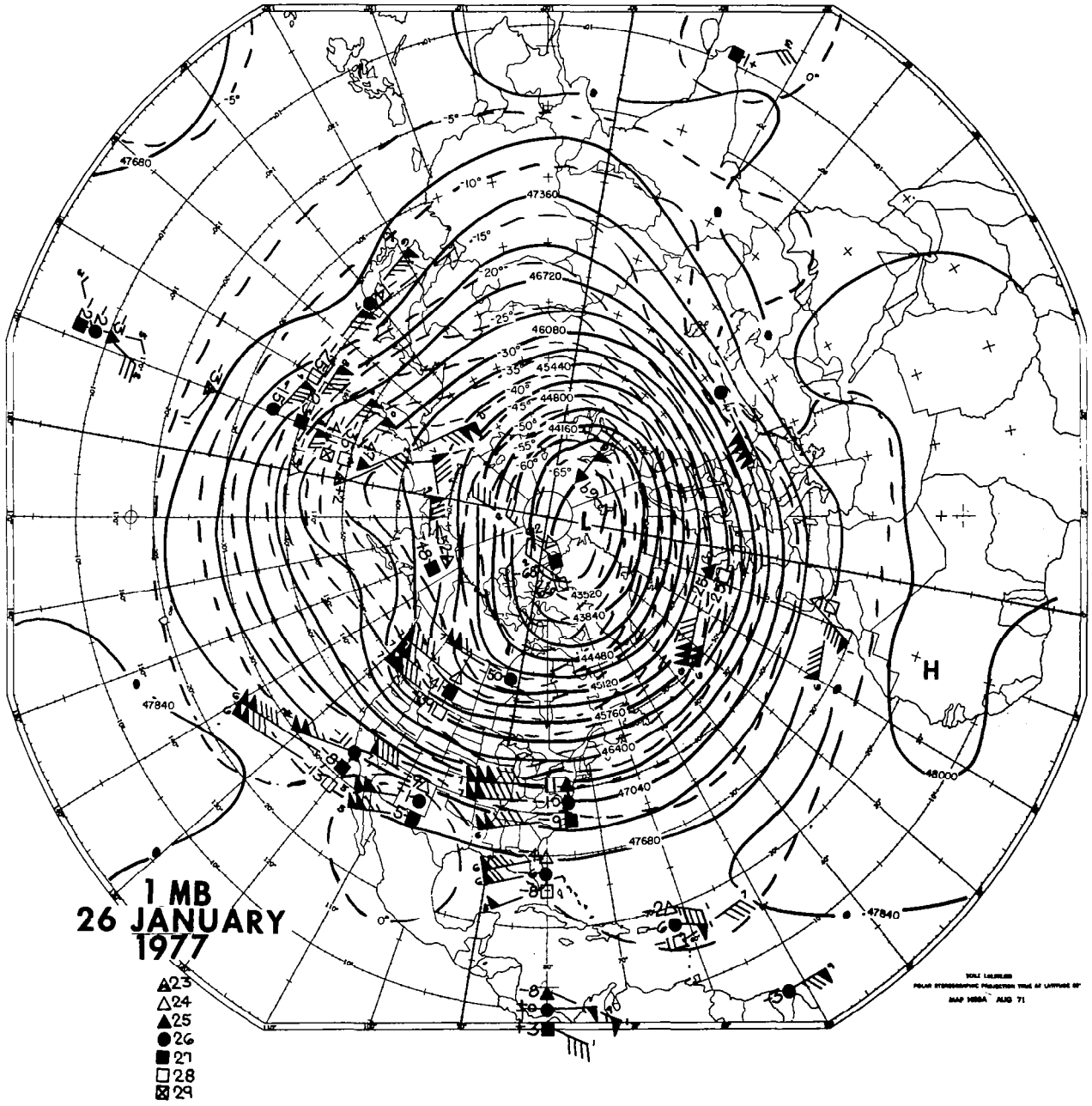
□ 28
⊠ 29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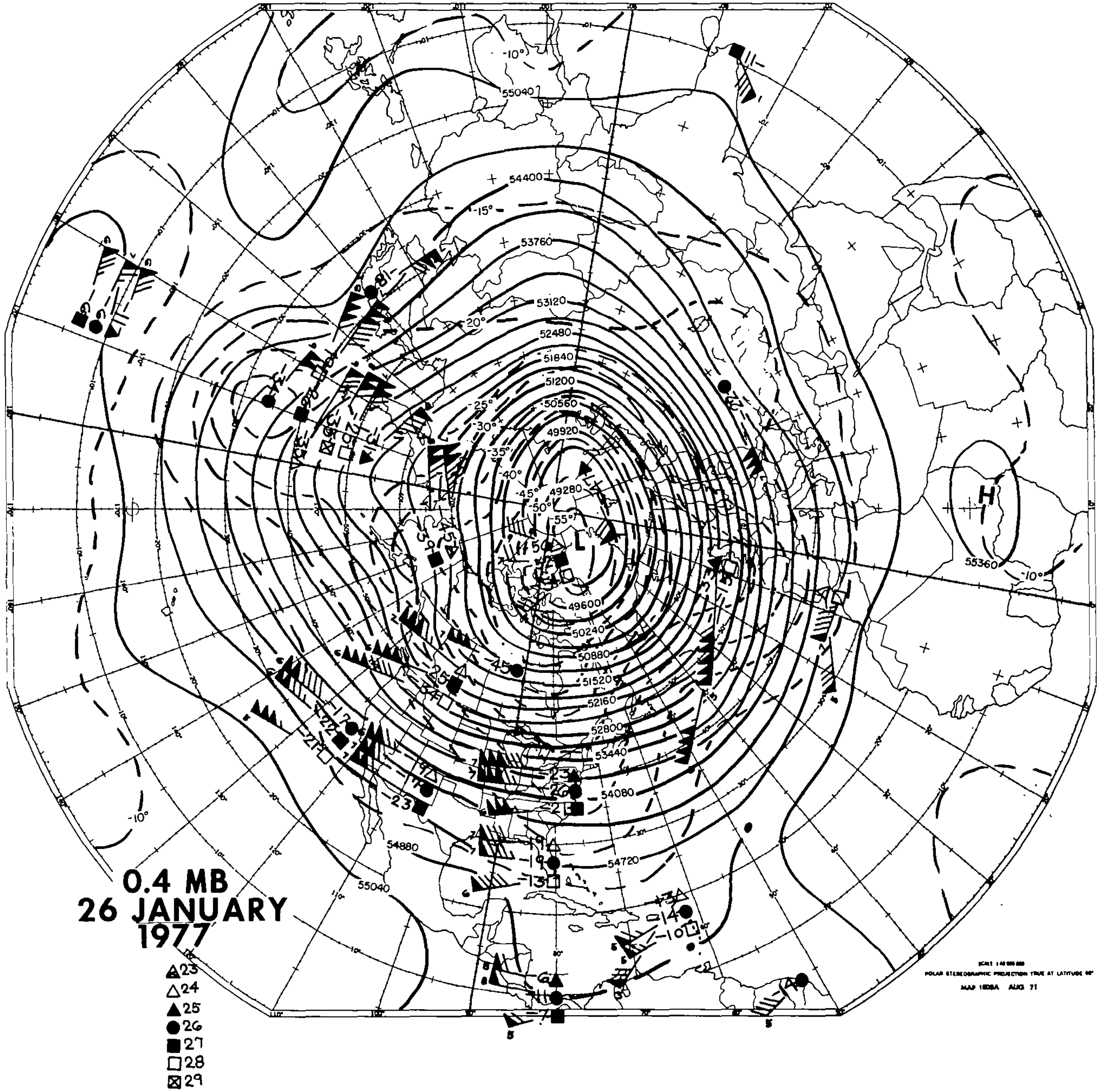
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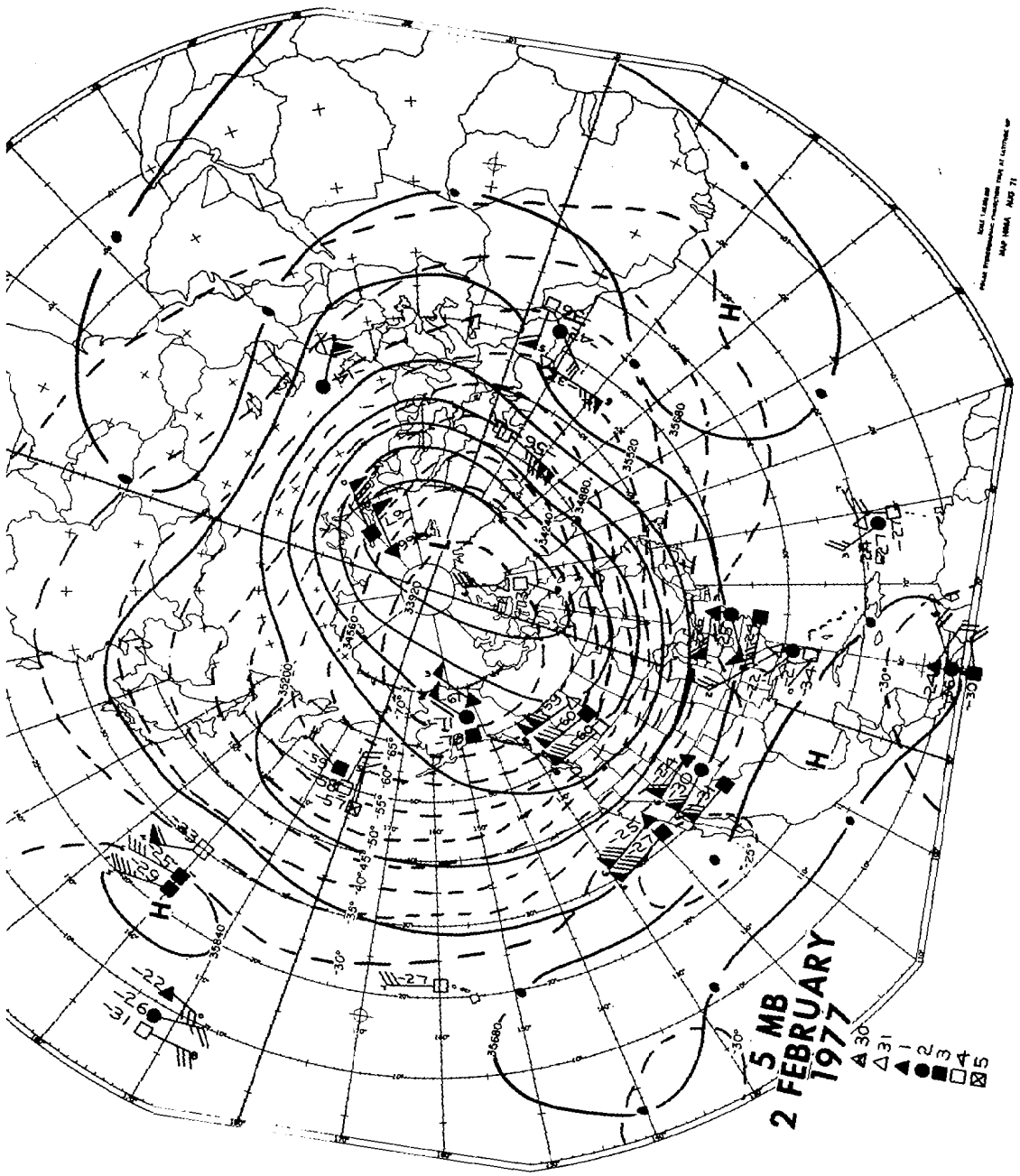
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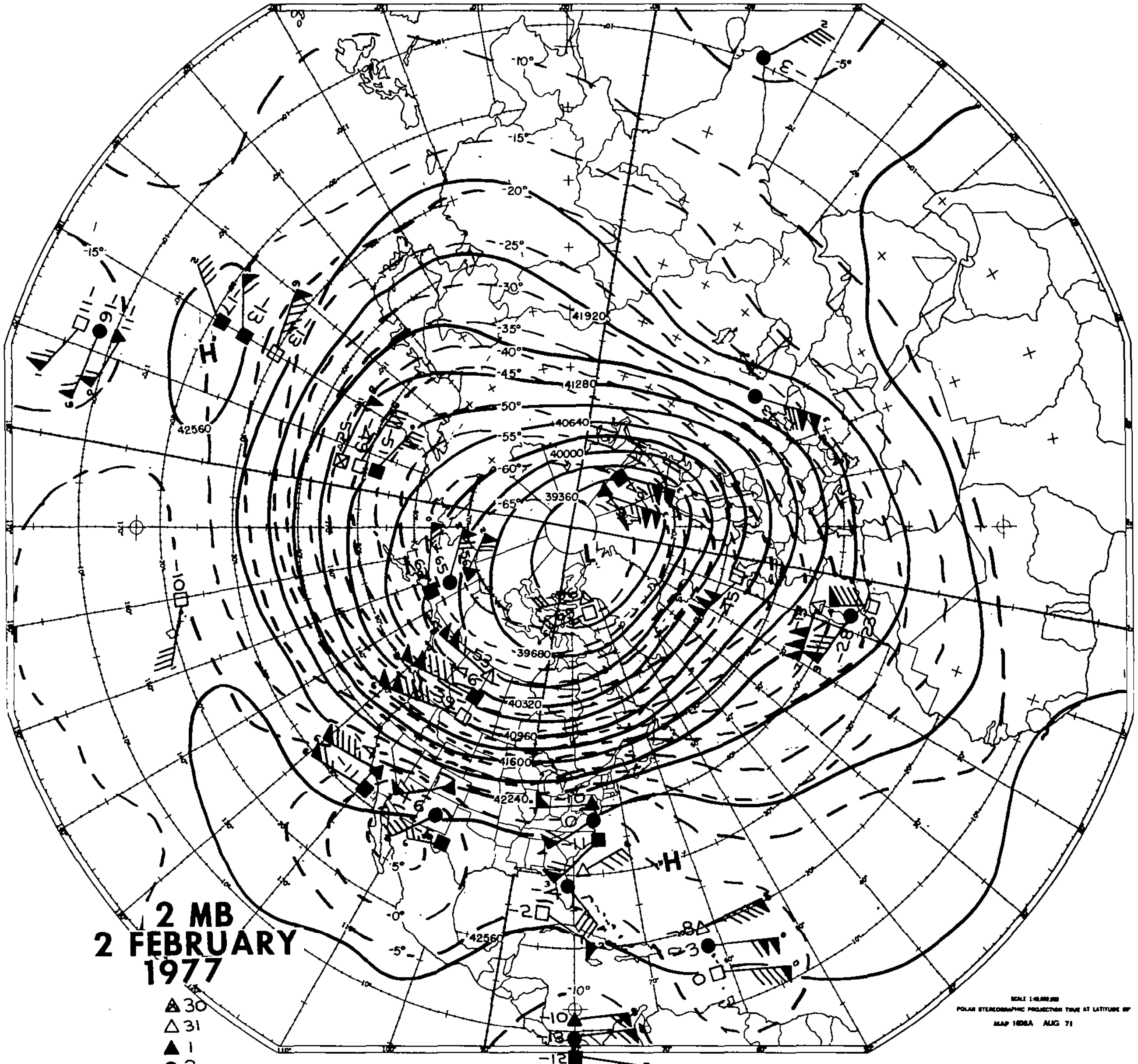

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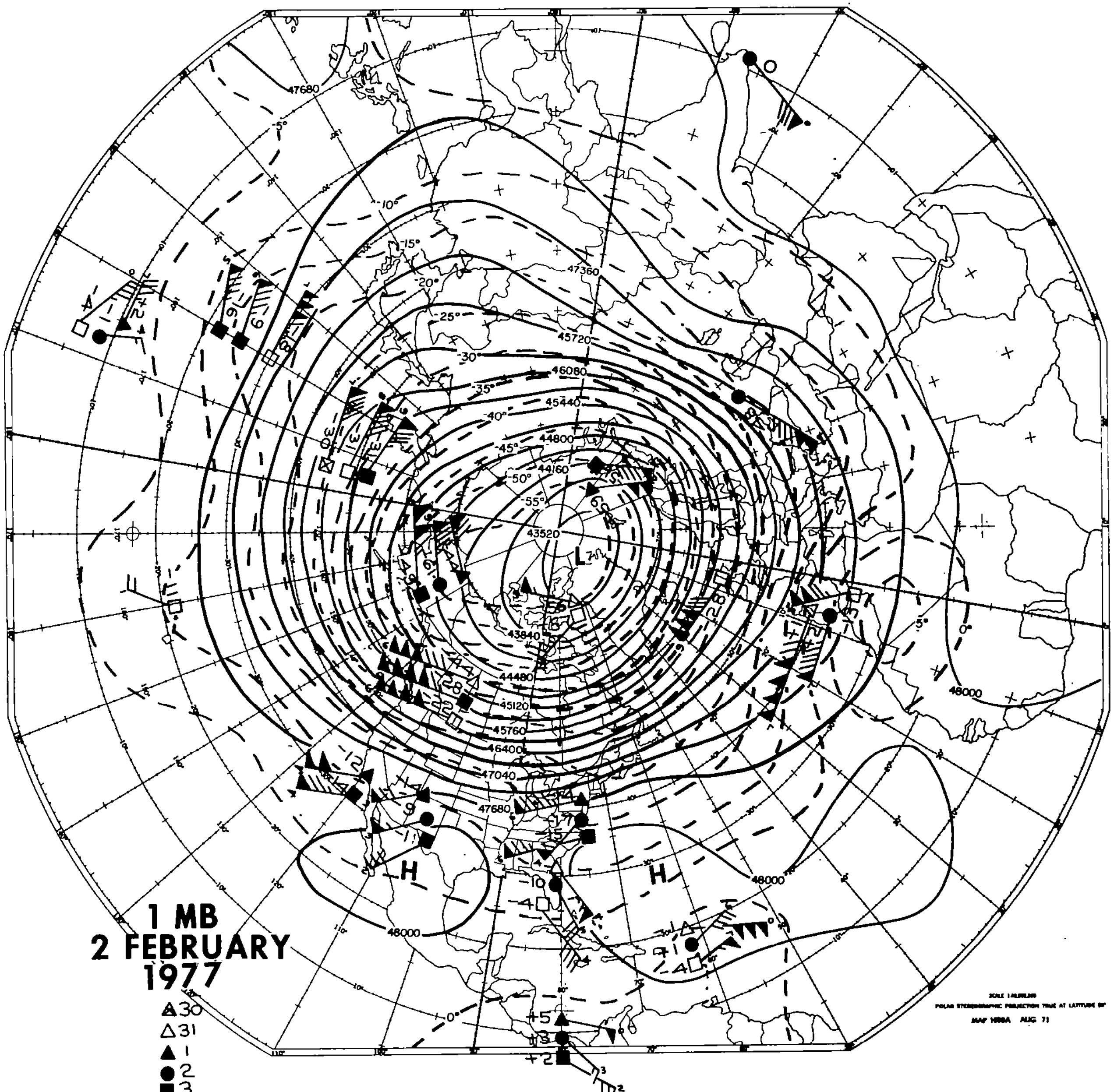
2 FEBRUARY 1977

- ▲ (shaded) 30
- △ 31
- ▲ 1
- ● 2
- ■ 3
- □ 4
- ⊠ 5



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2 FEBRUARY
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▲30 (hatched triangle)
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●2
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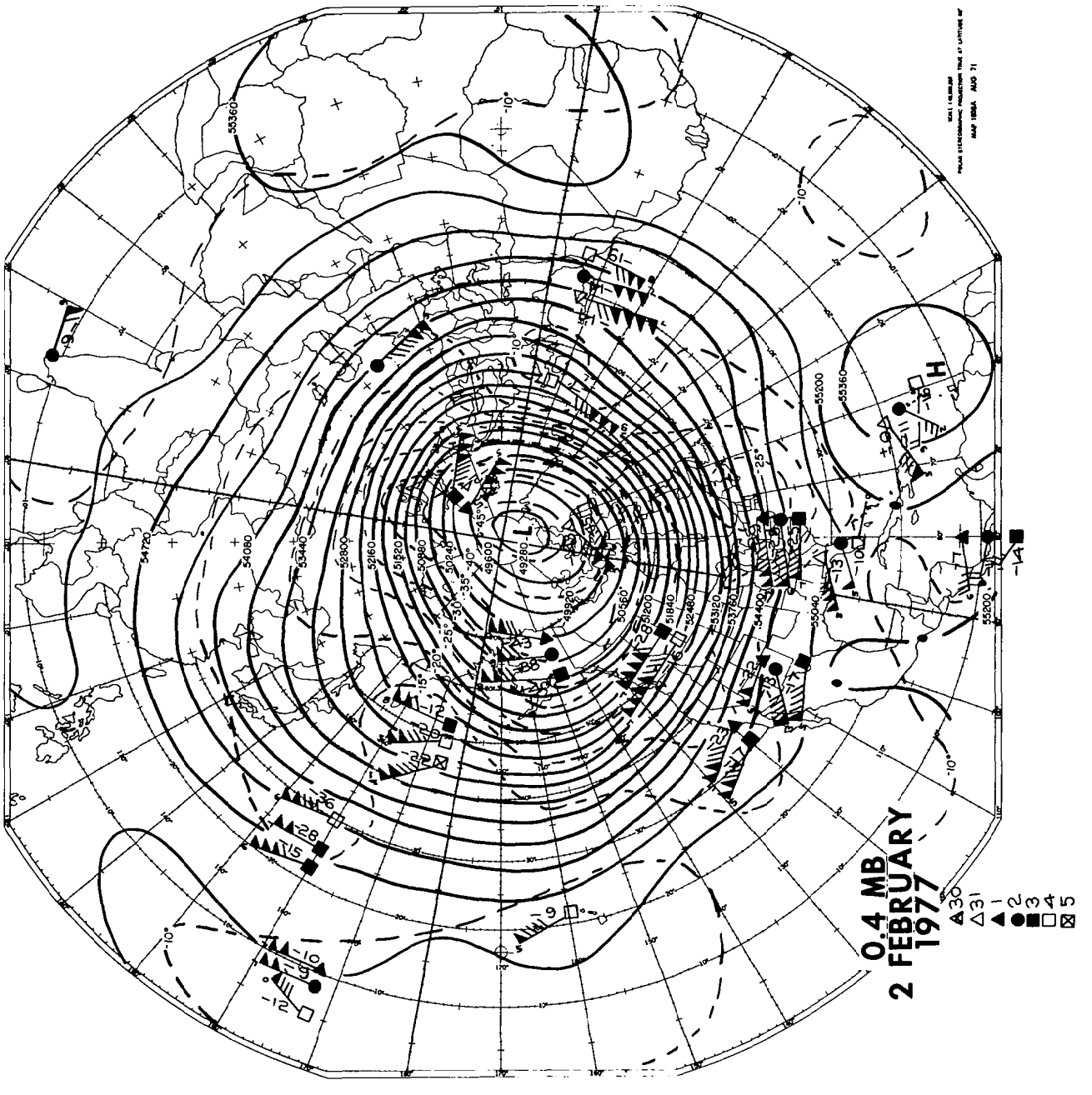
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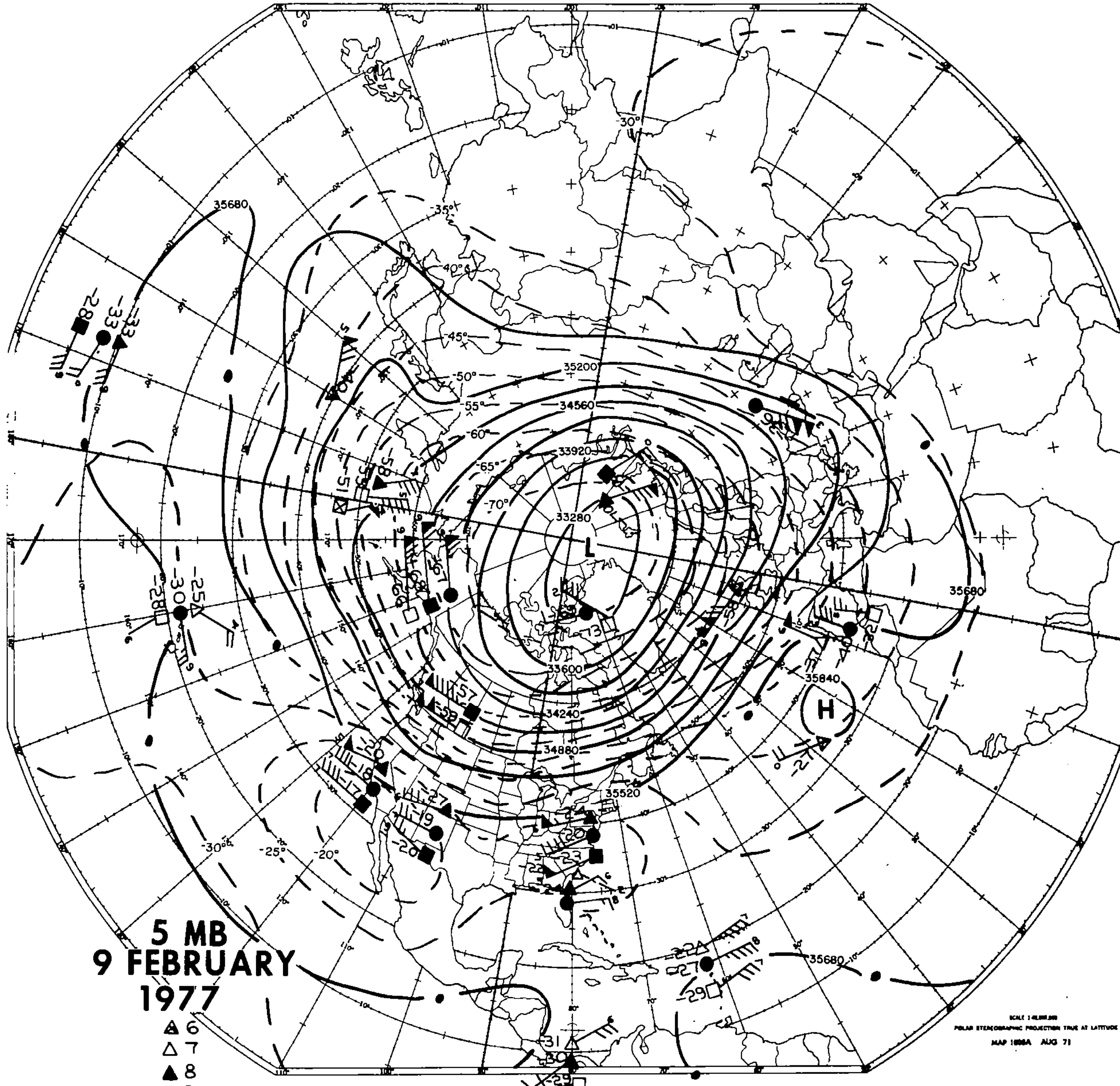

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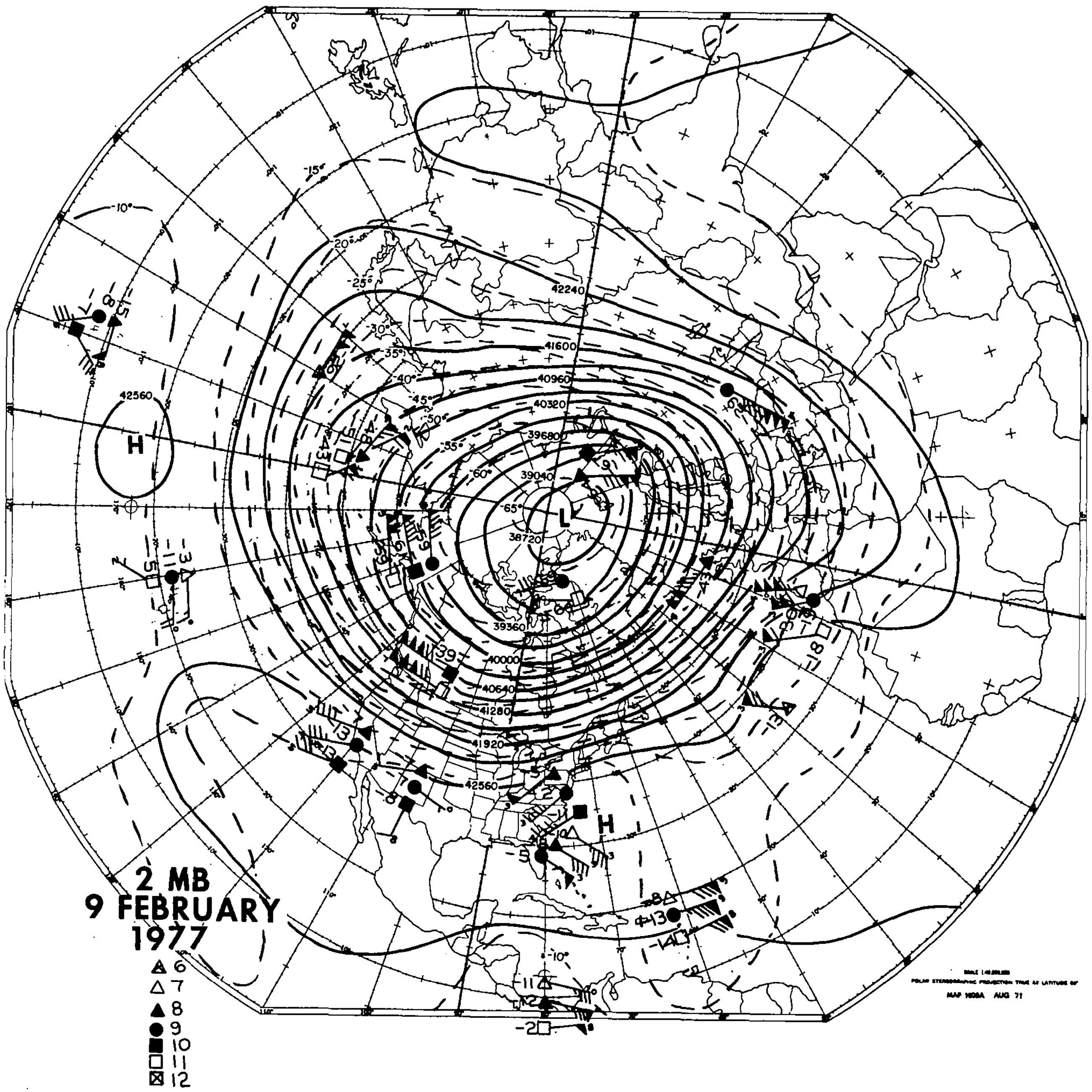
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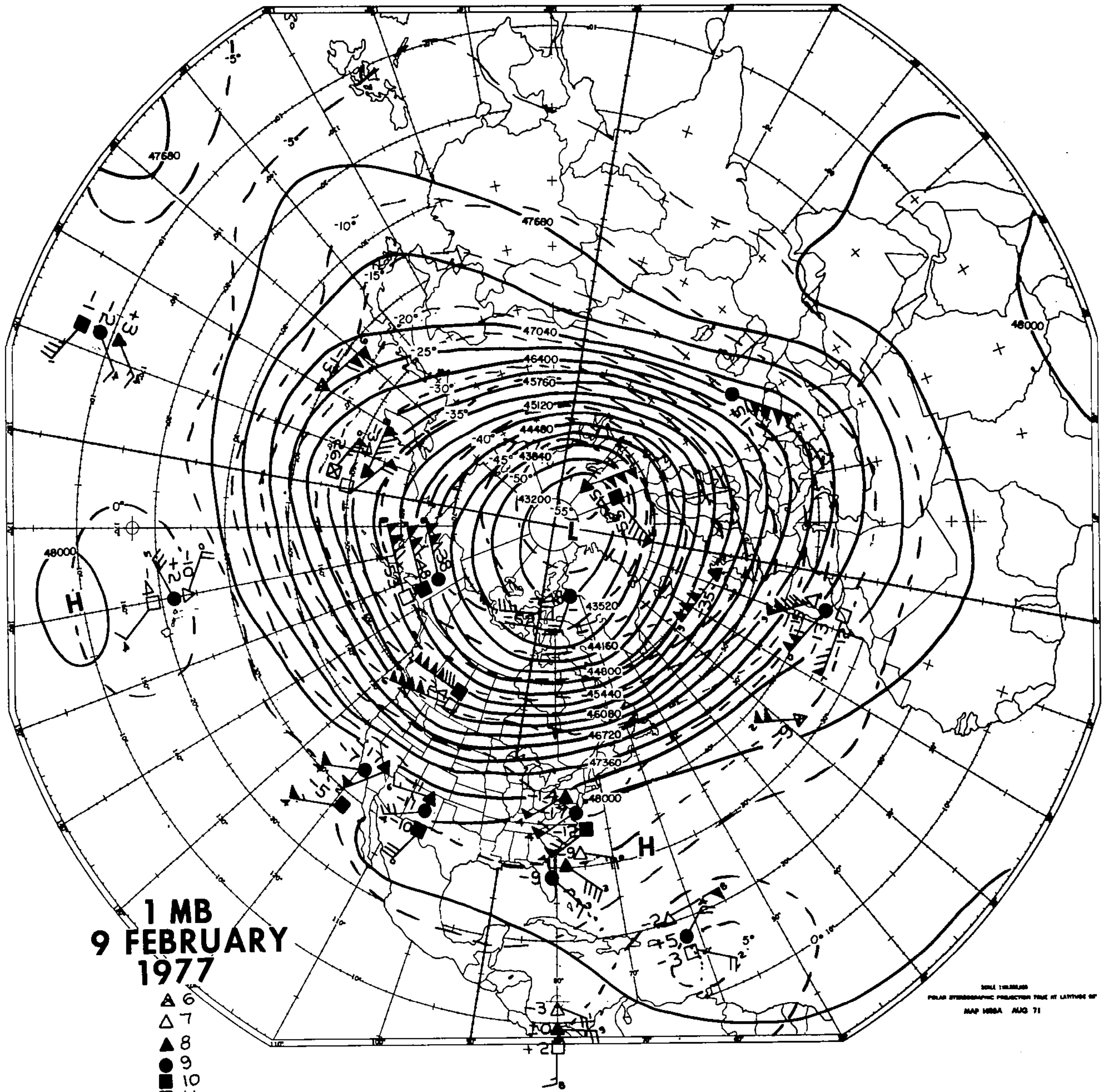

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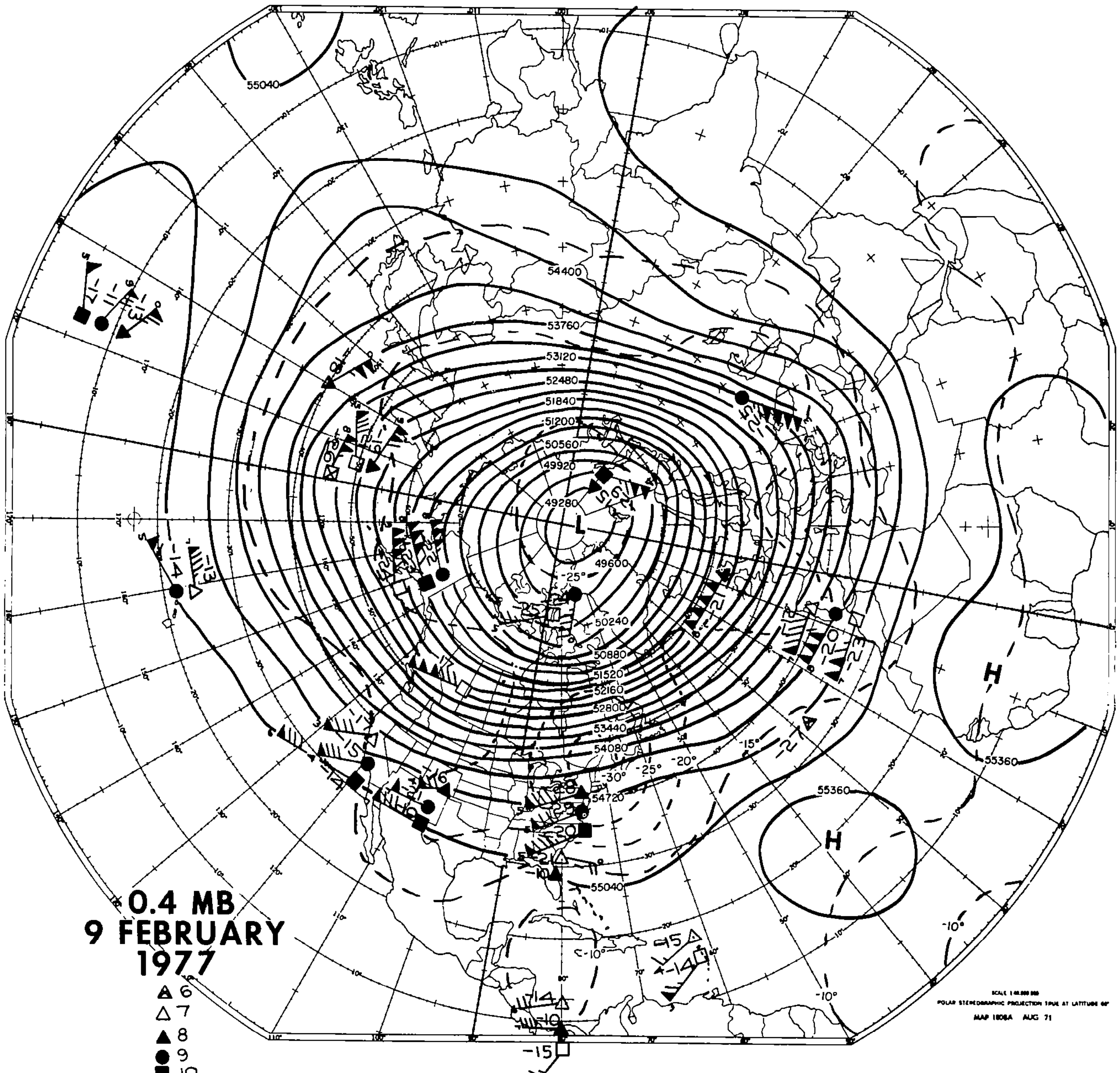

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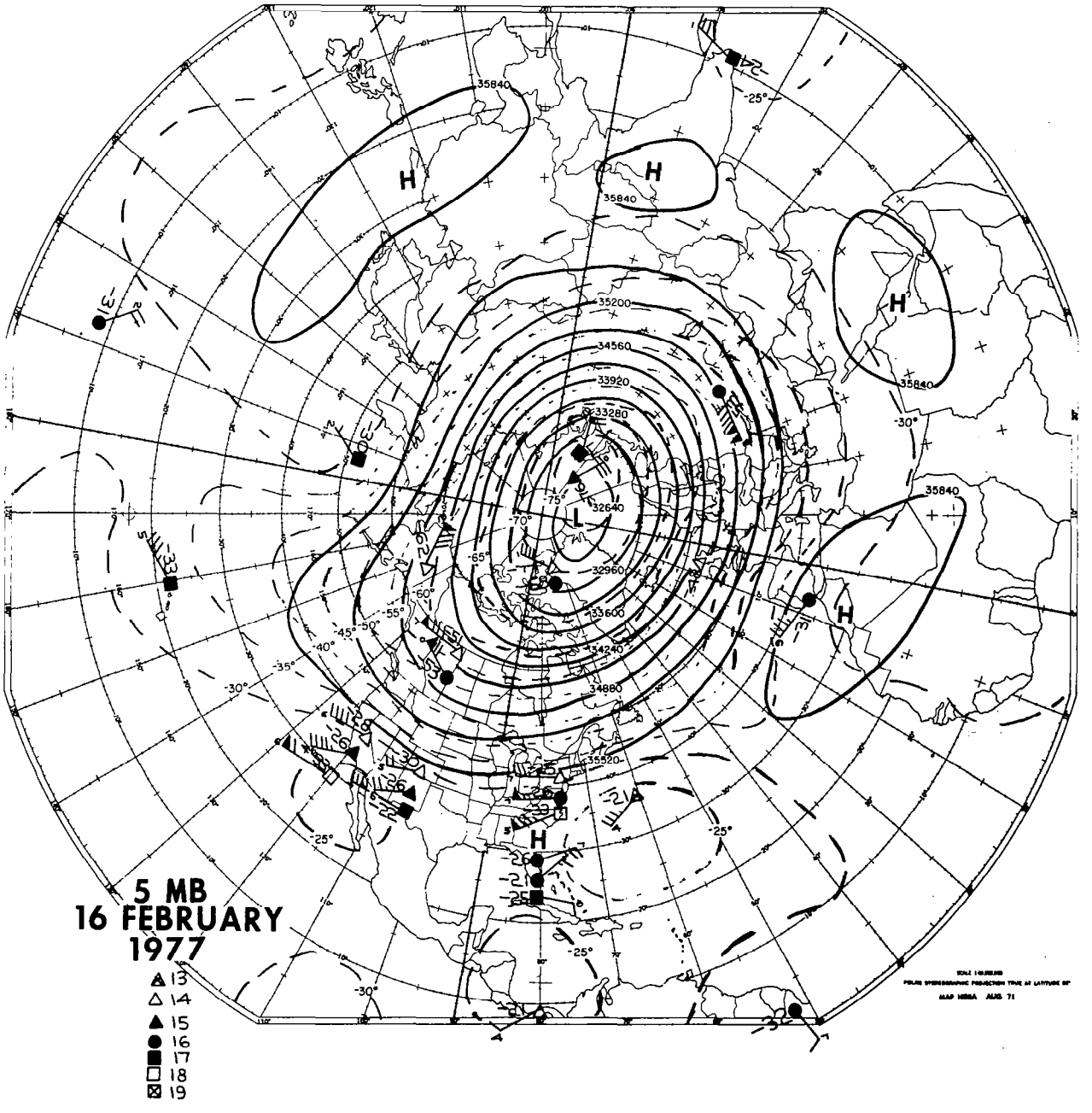
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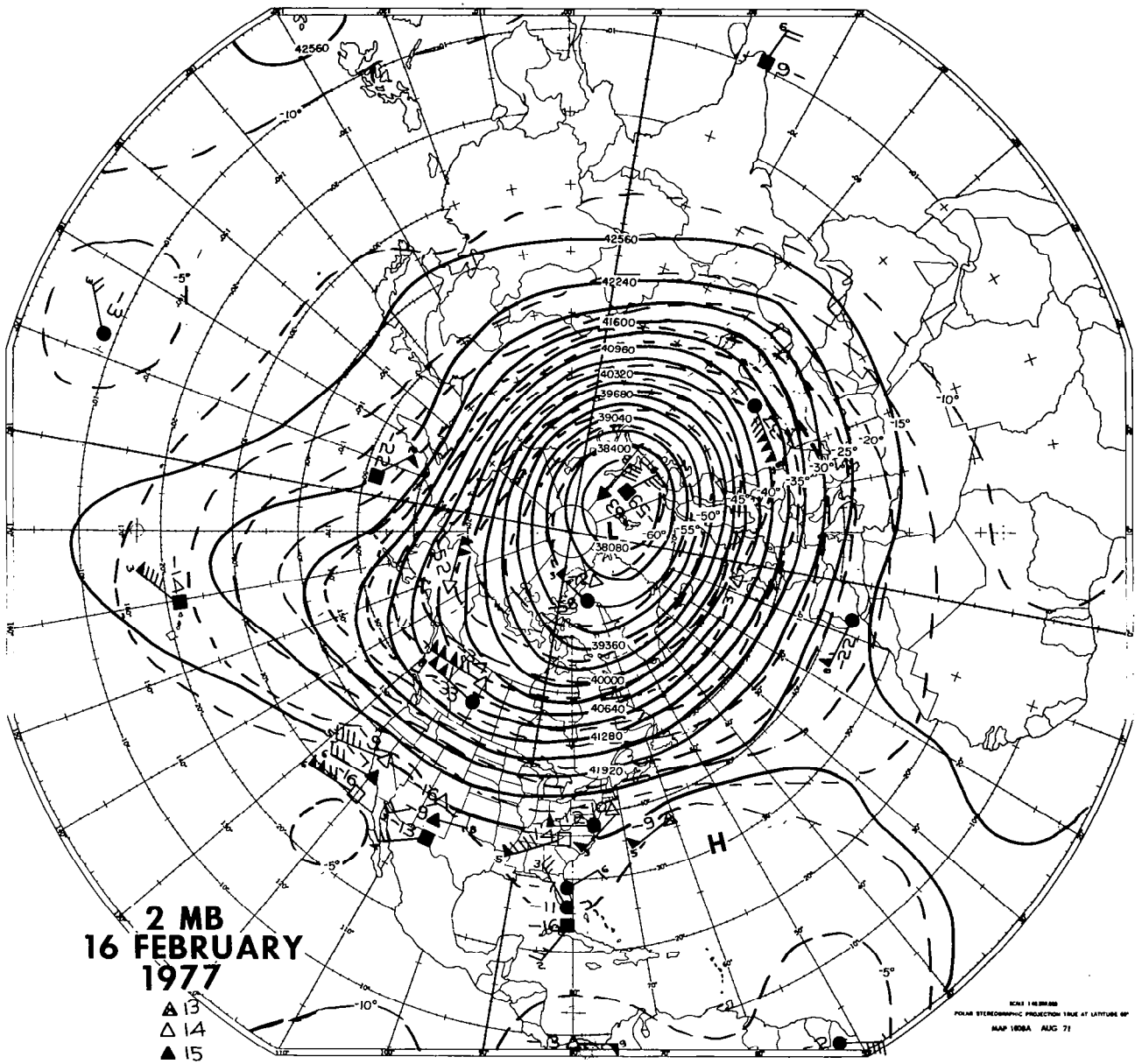
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16 FEBRUARY
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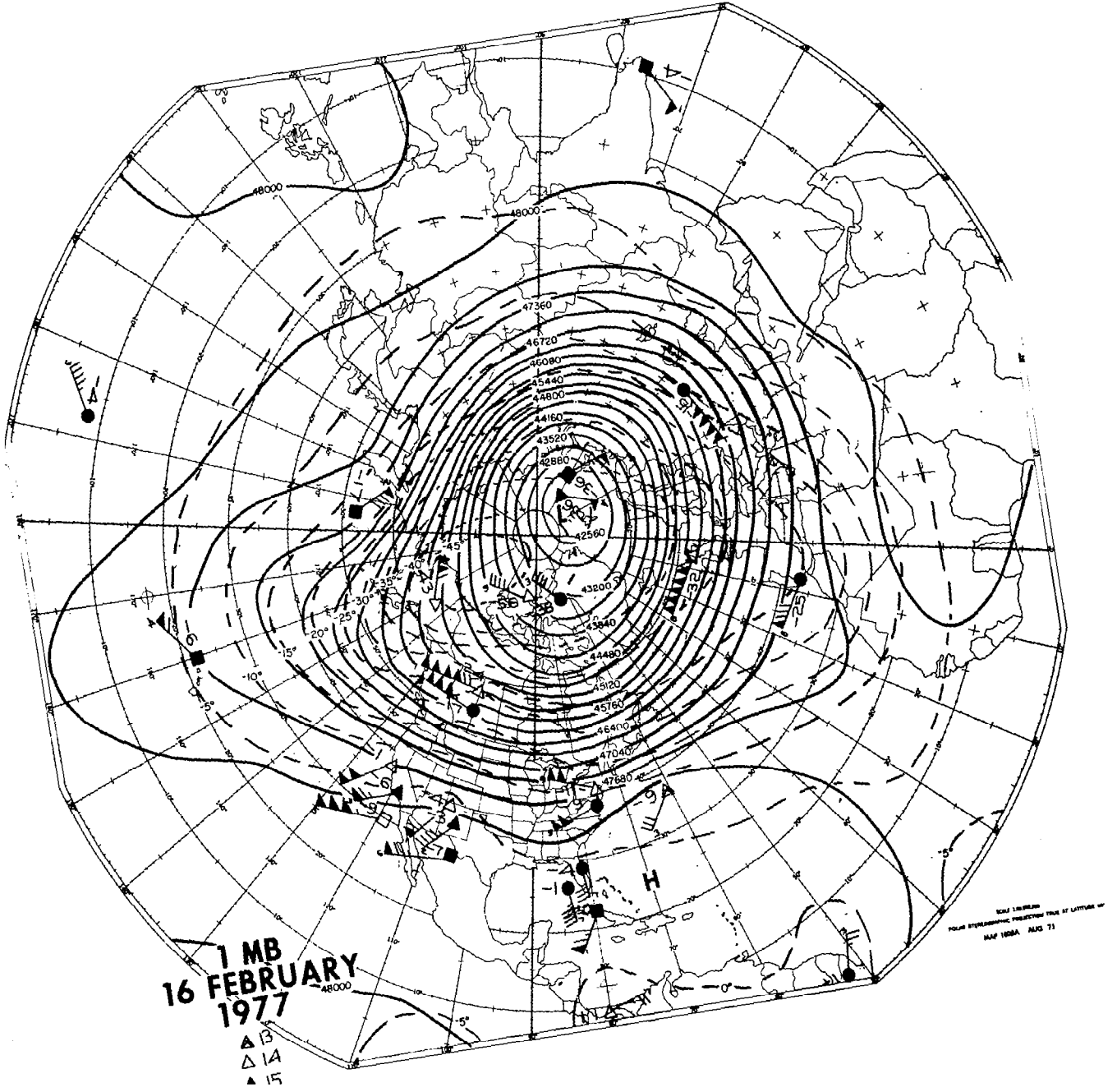
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 160BA AUG 71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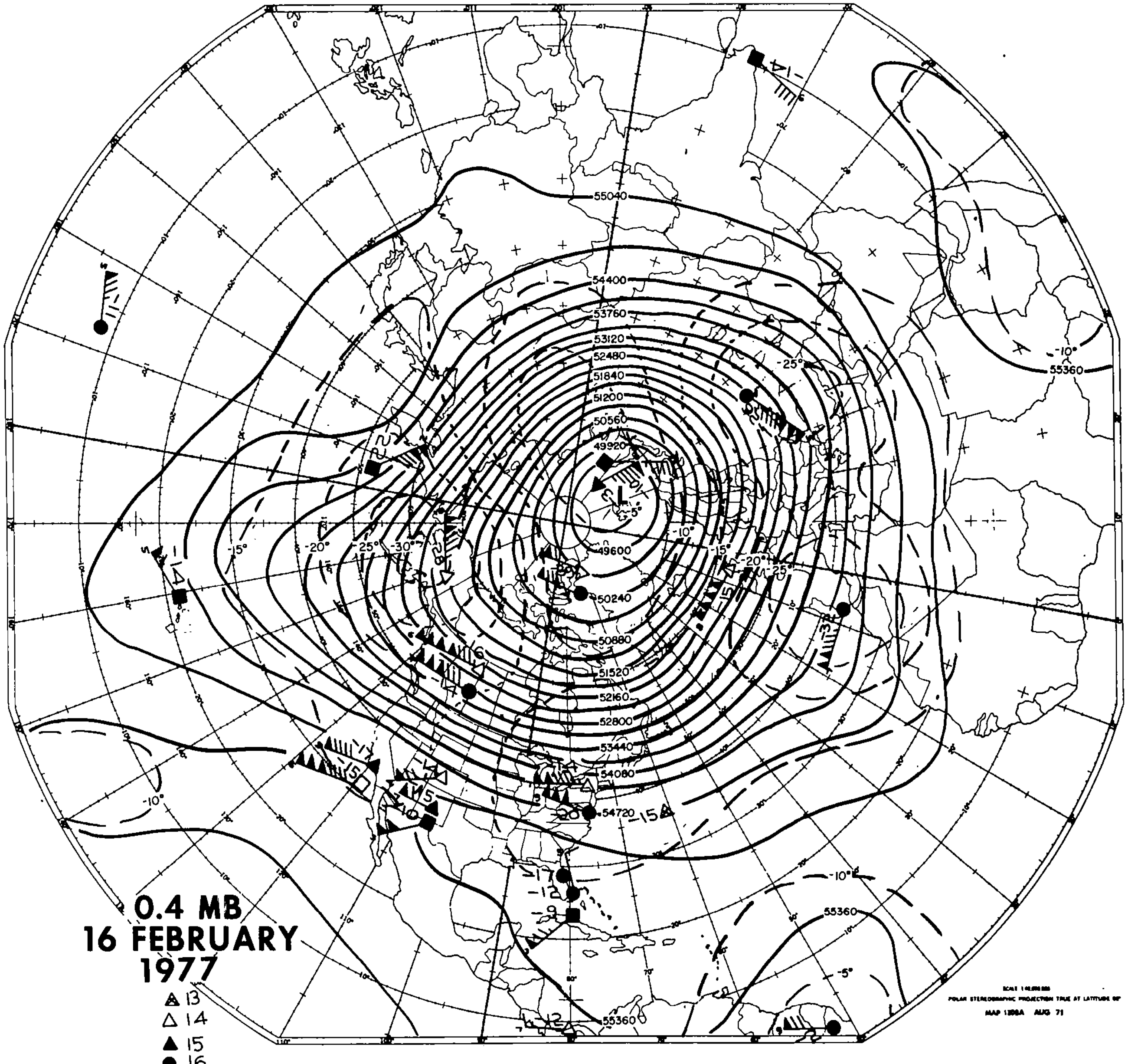

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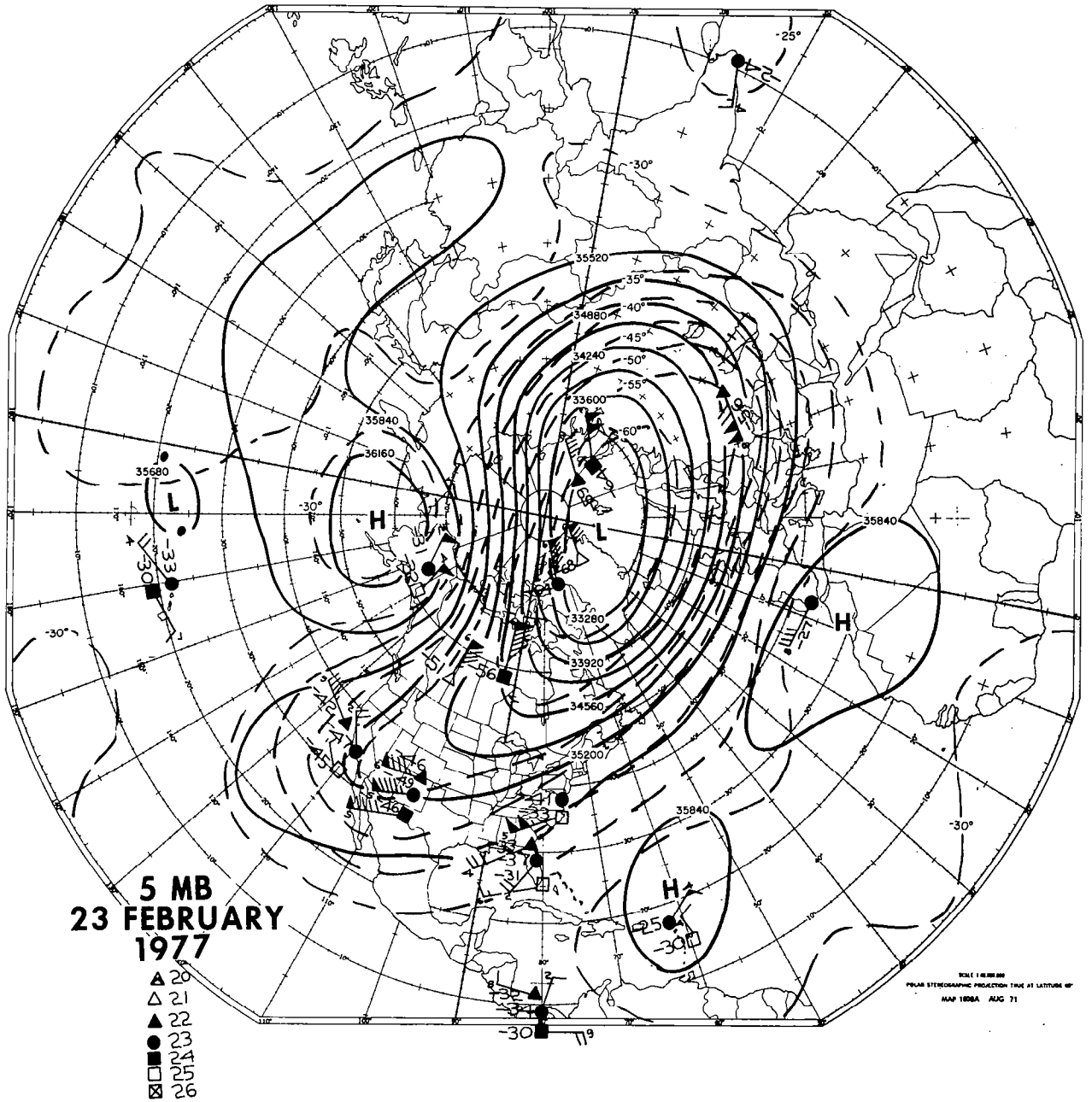
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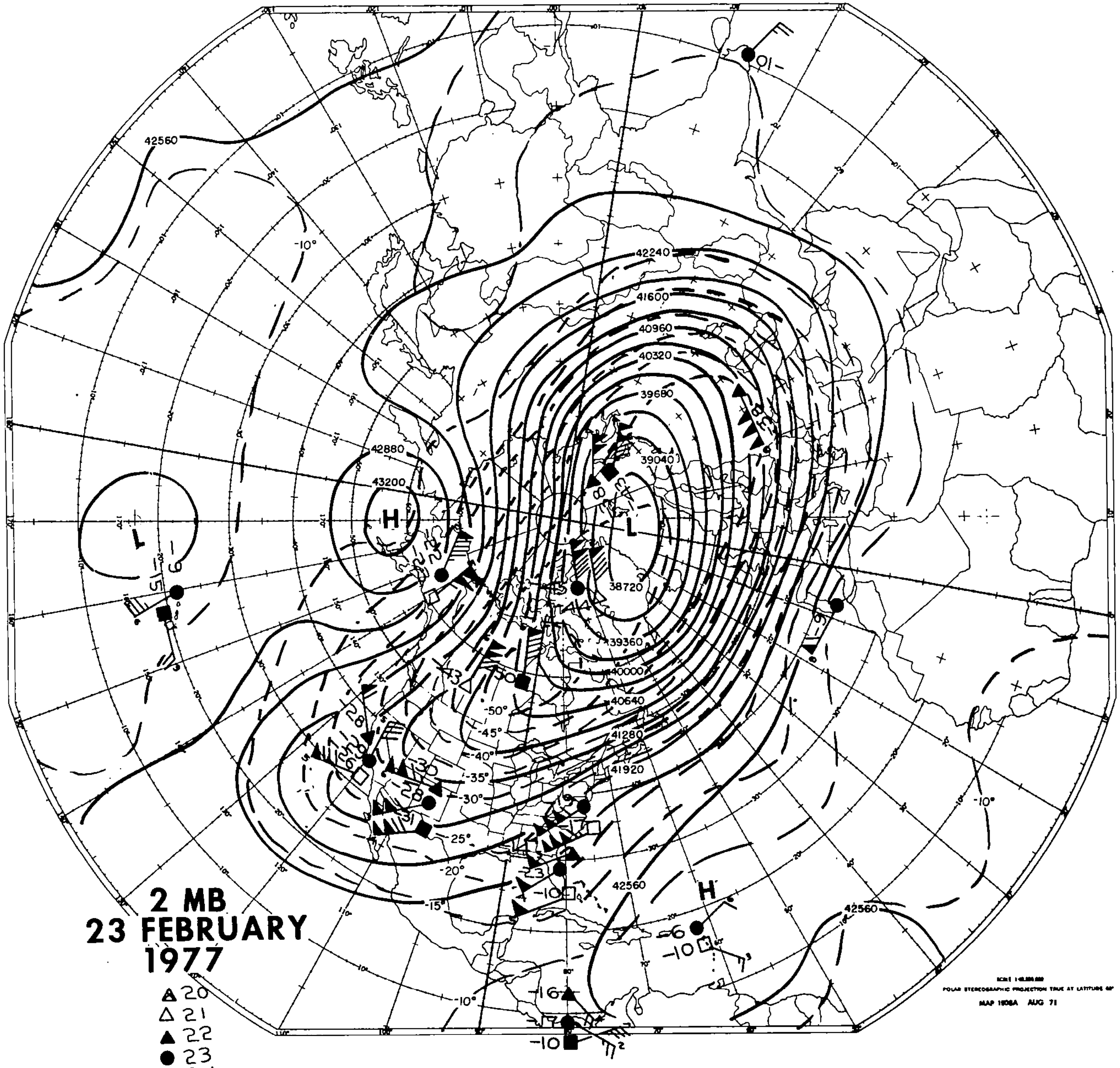
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1808A AUG 71



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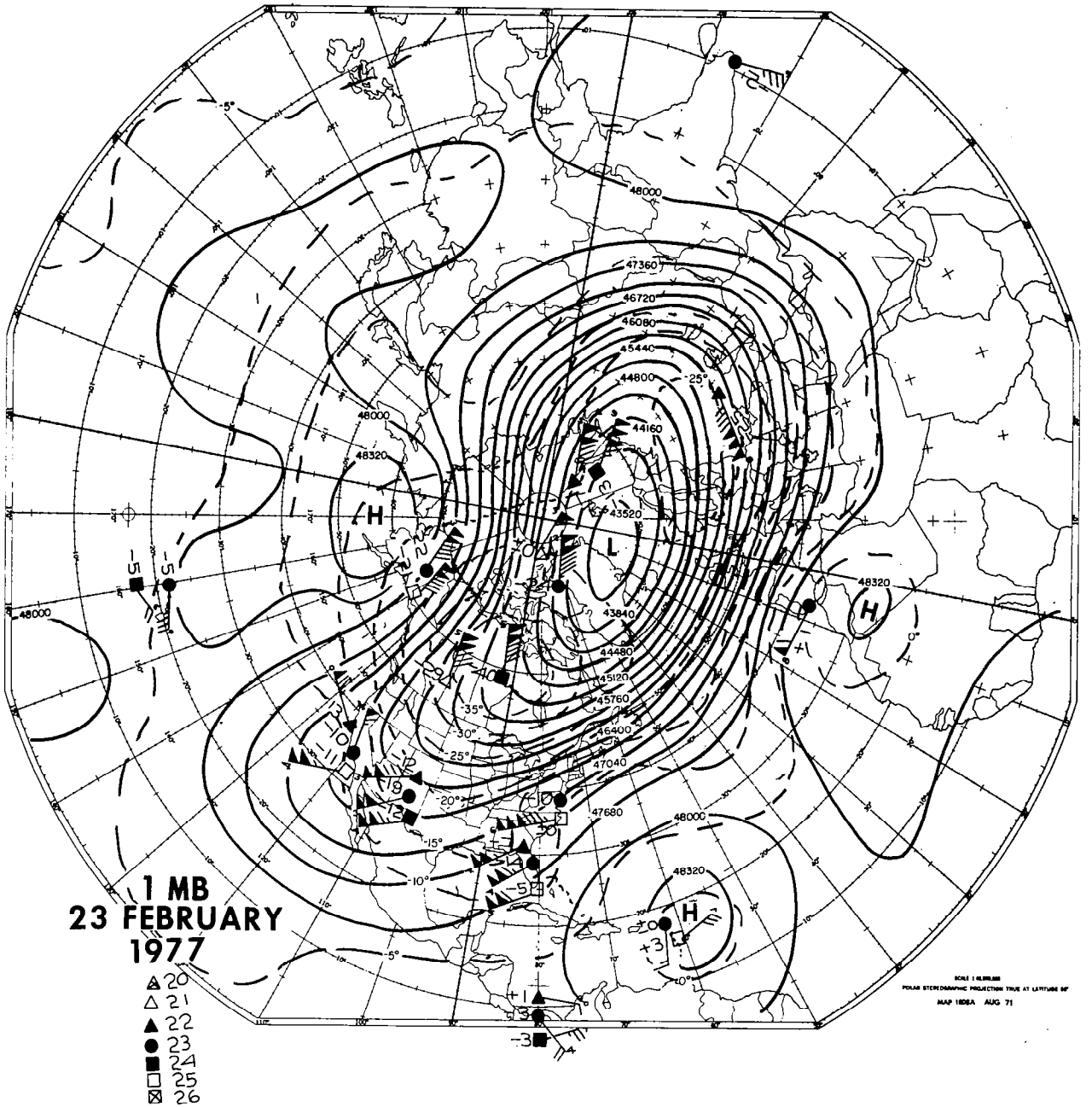
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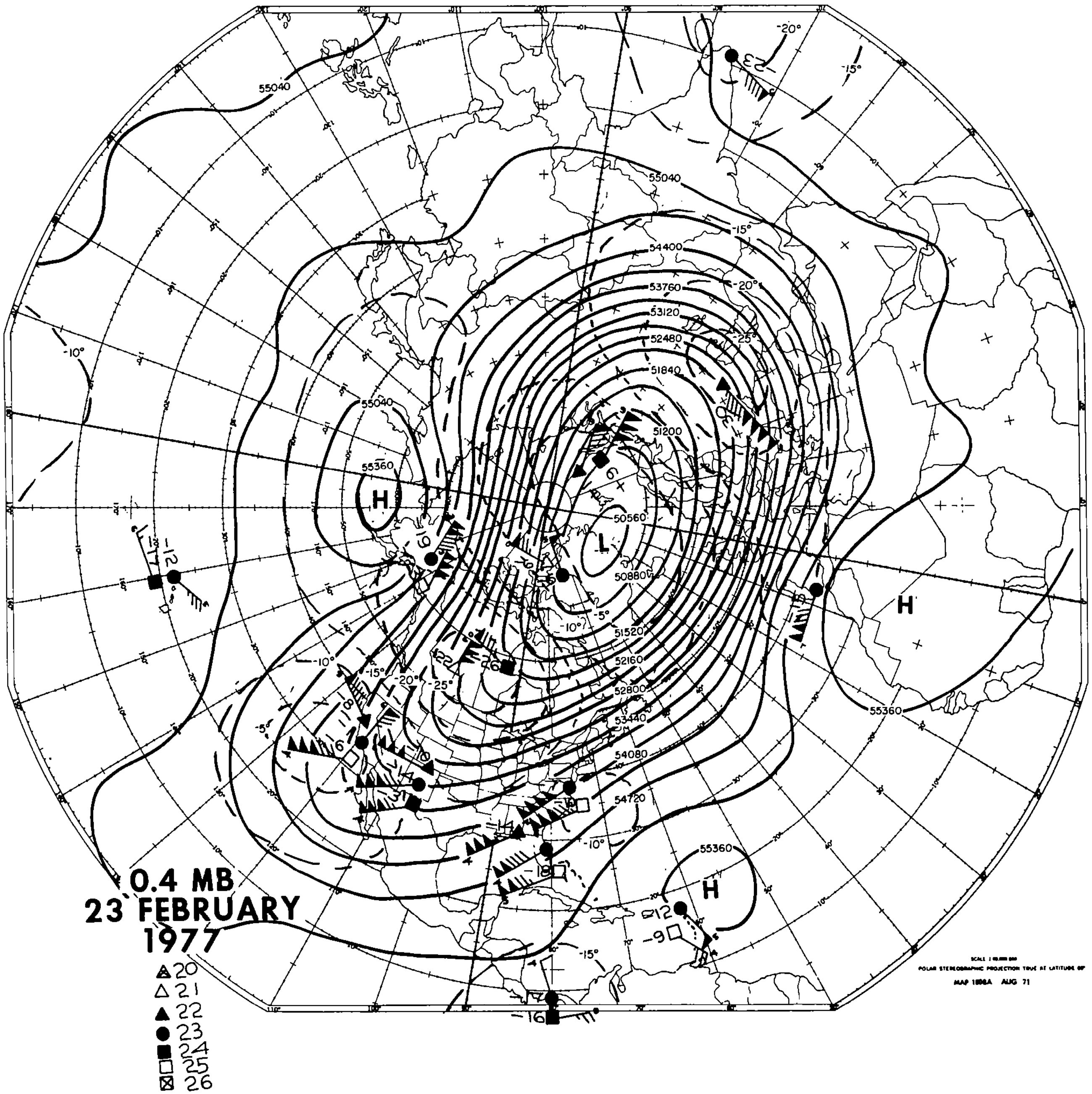
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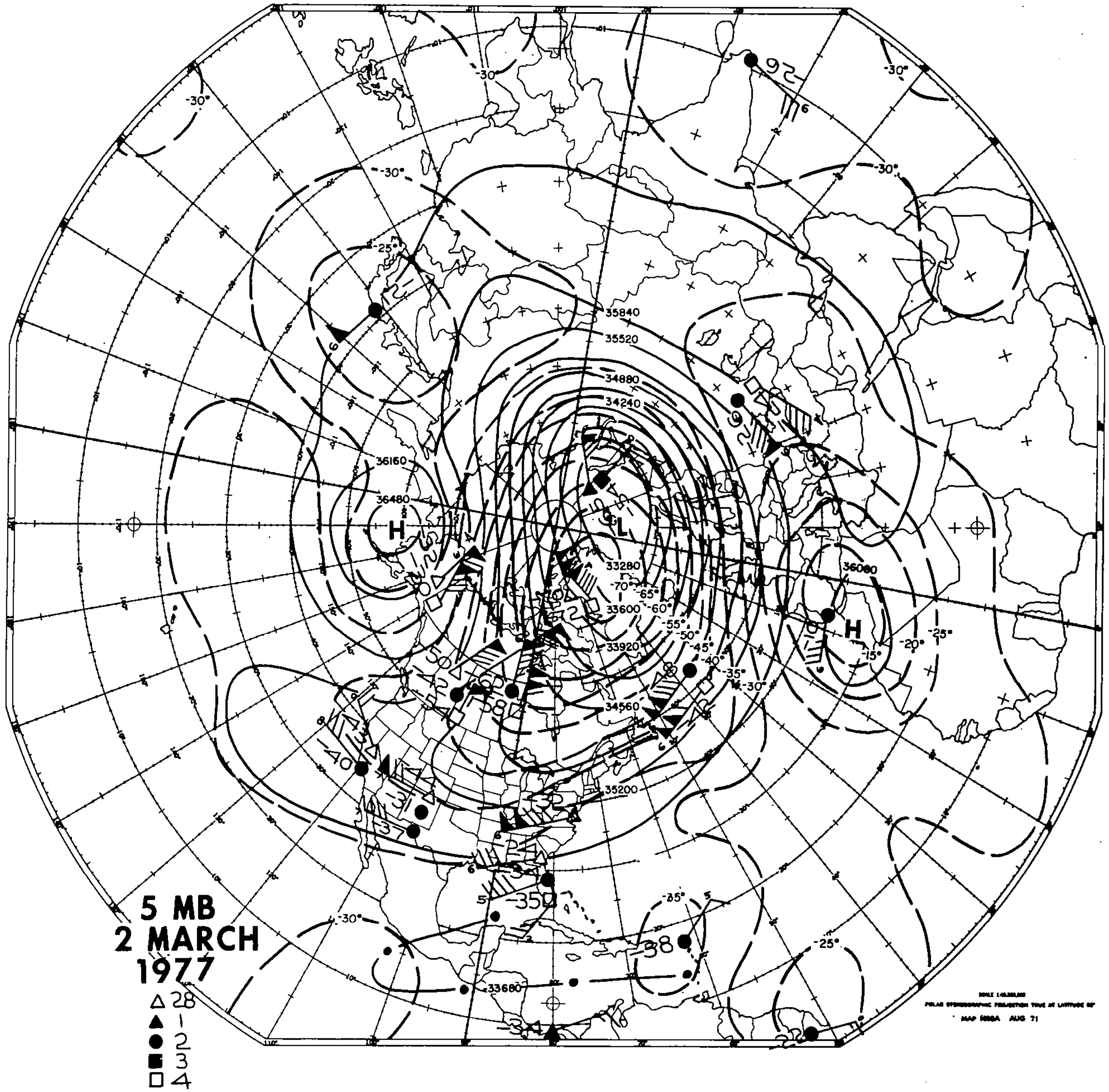
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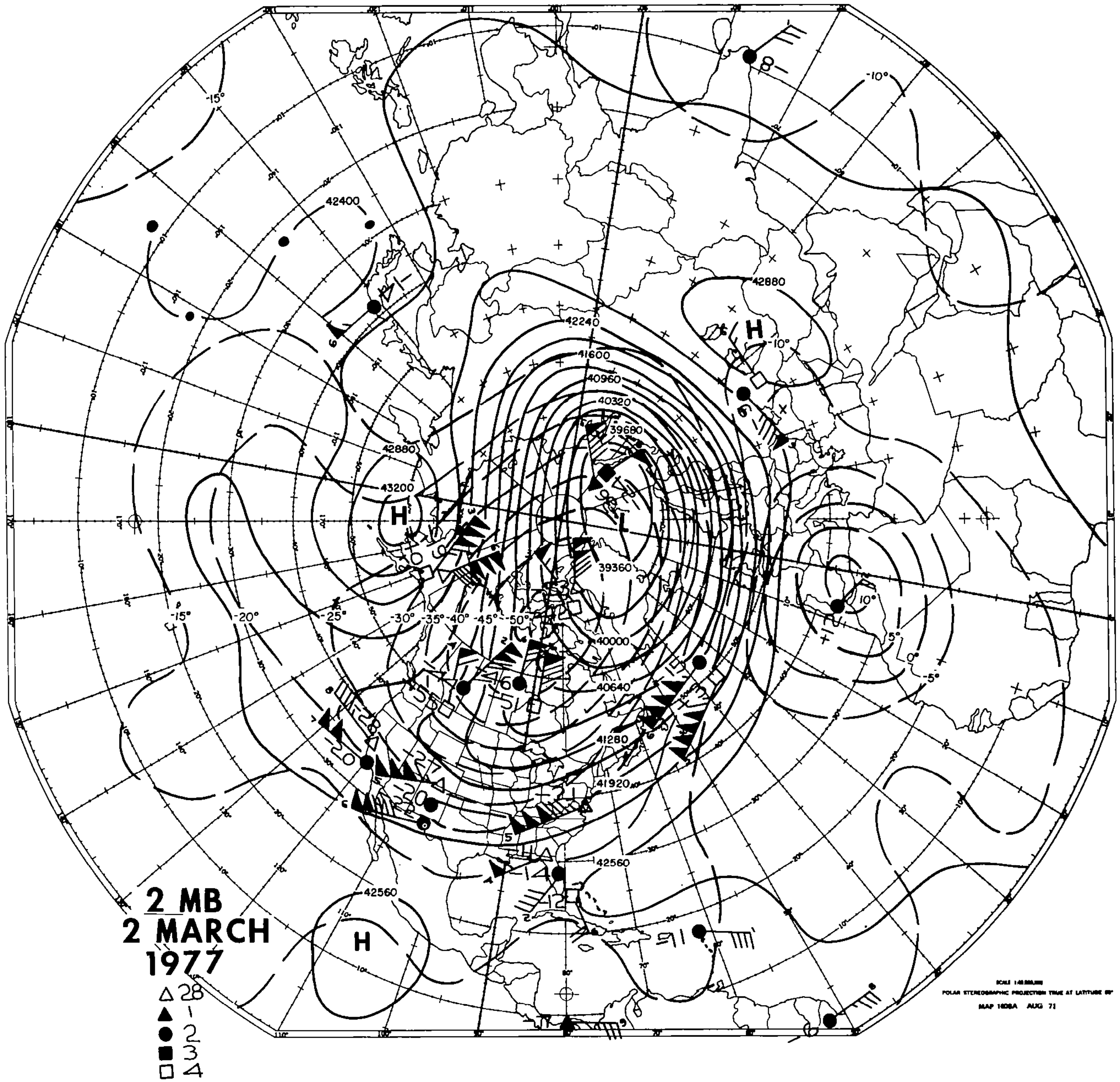
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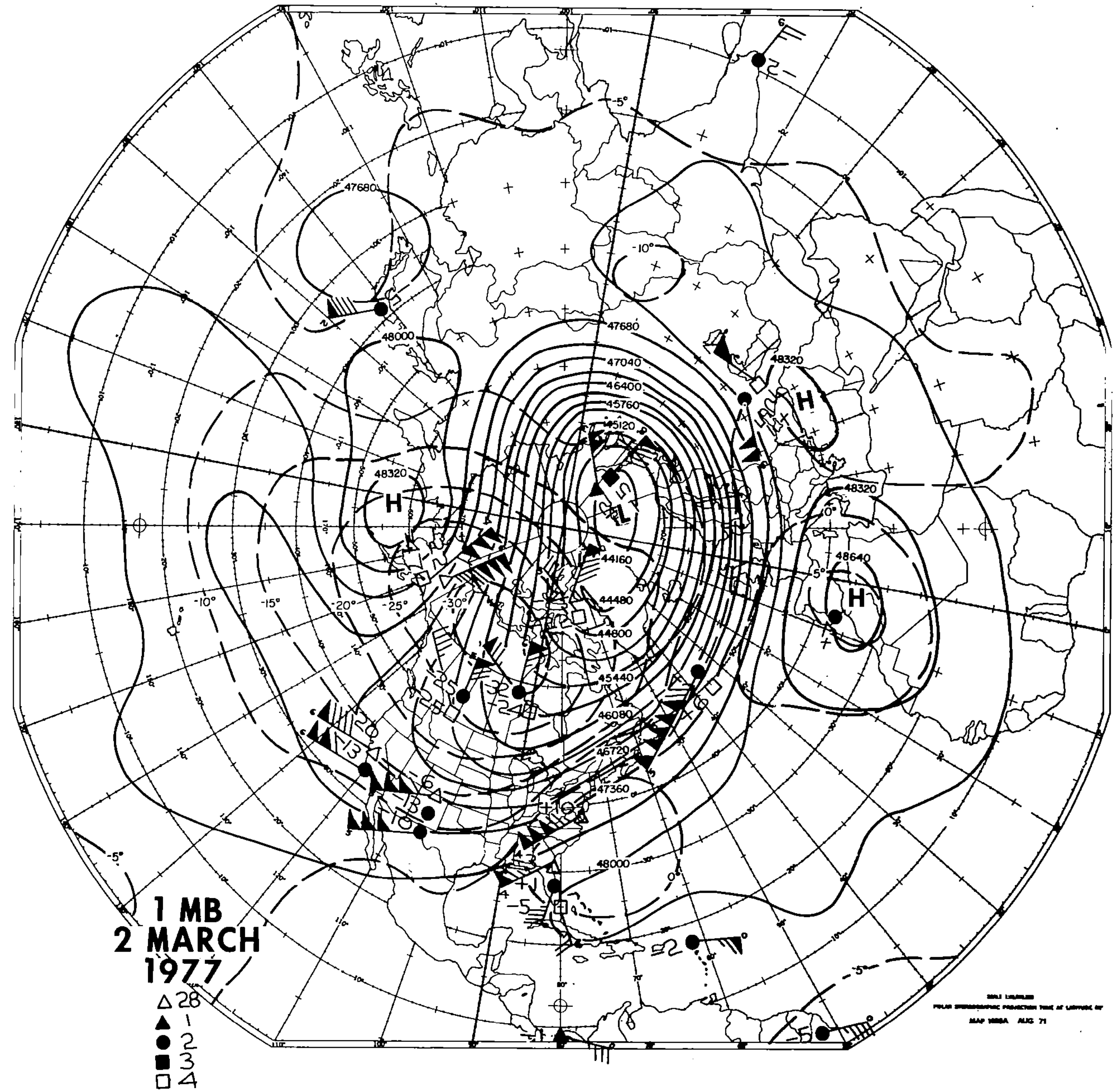
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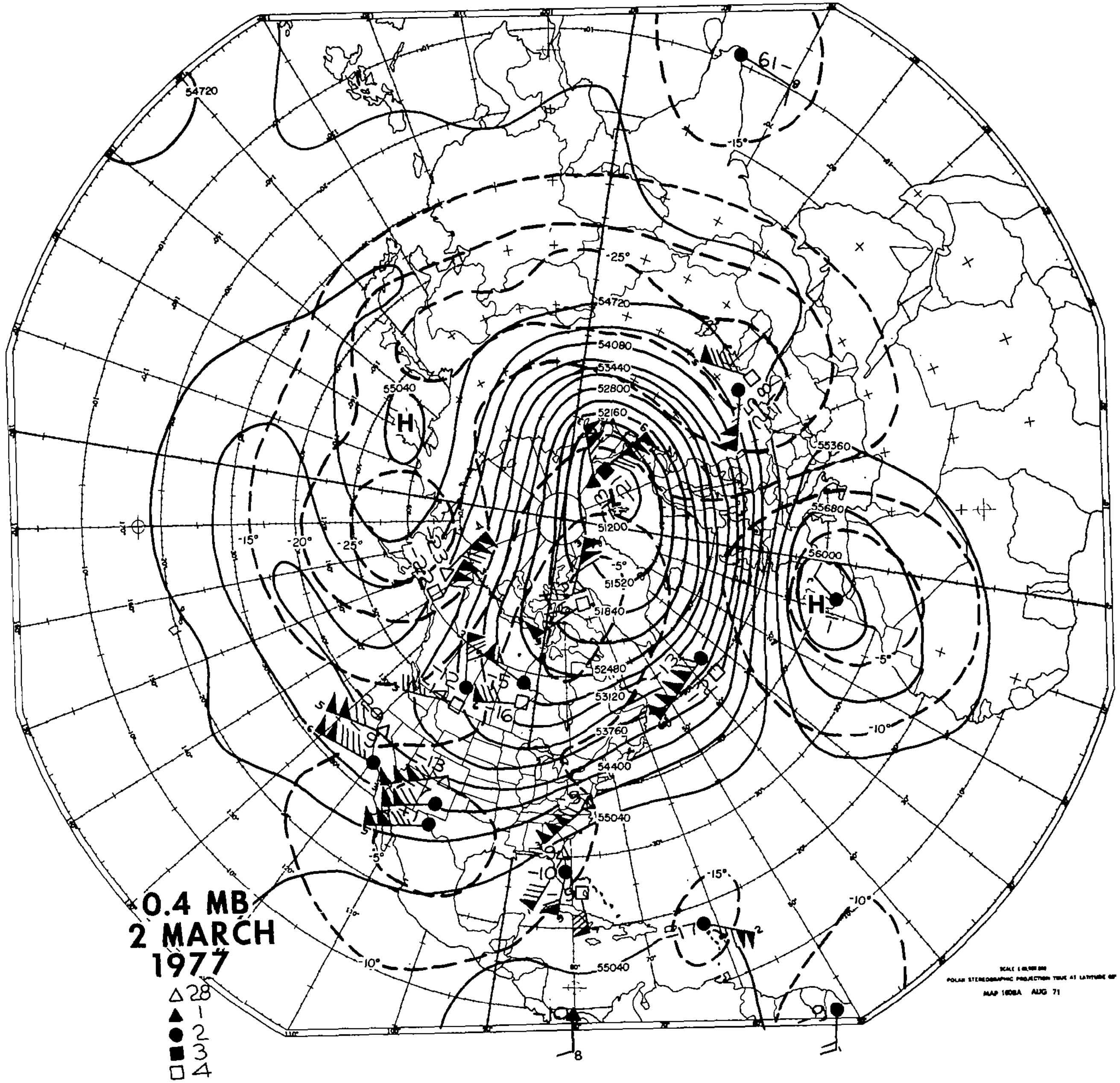
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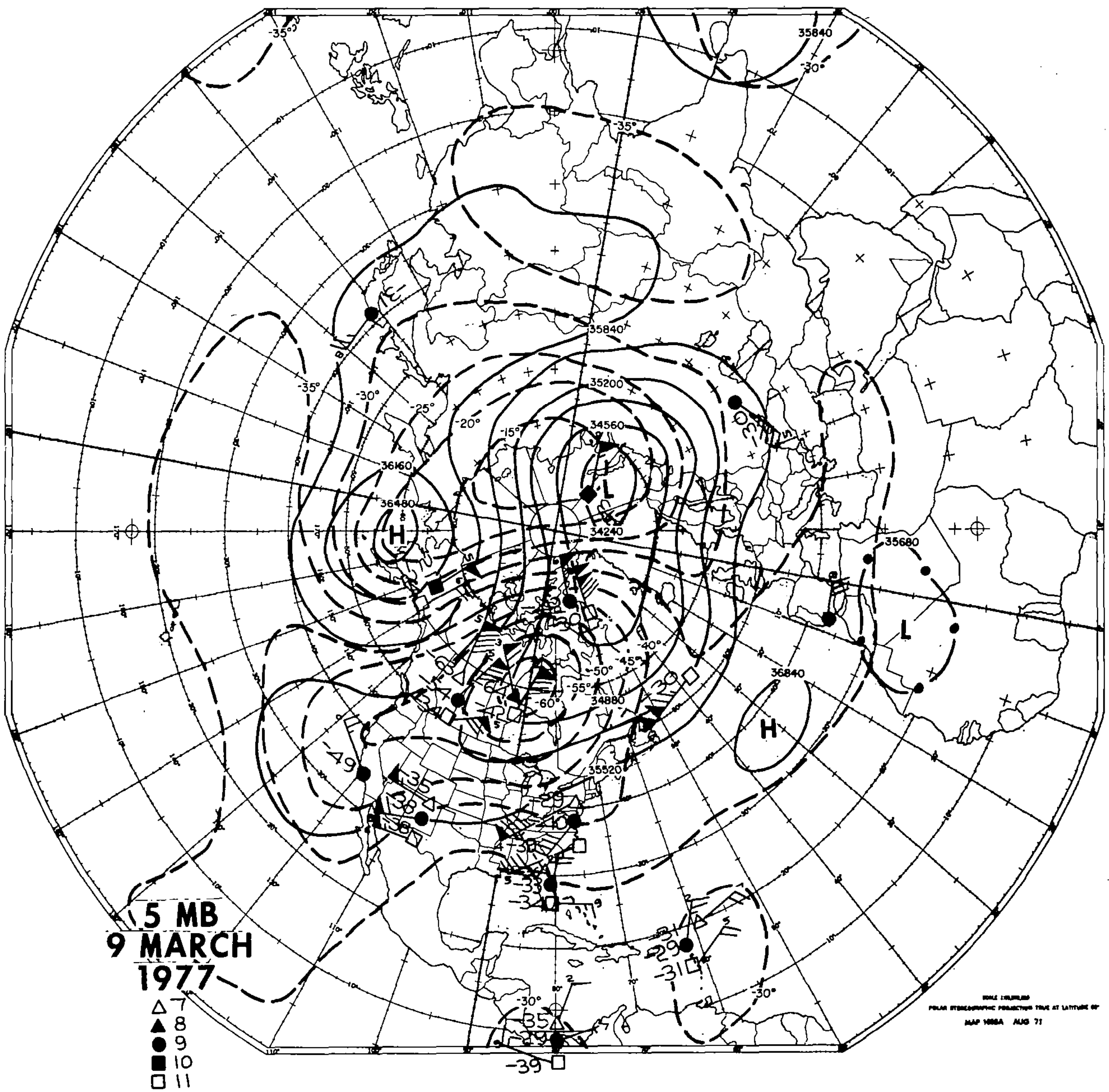
MAP 1608A AUG 71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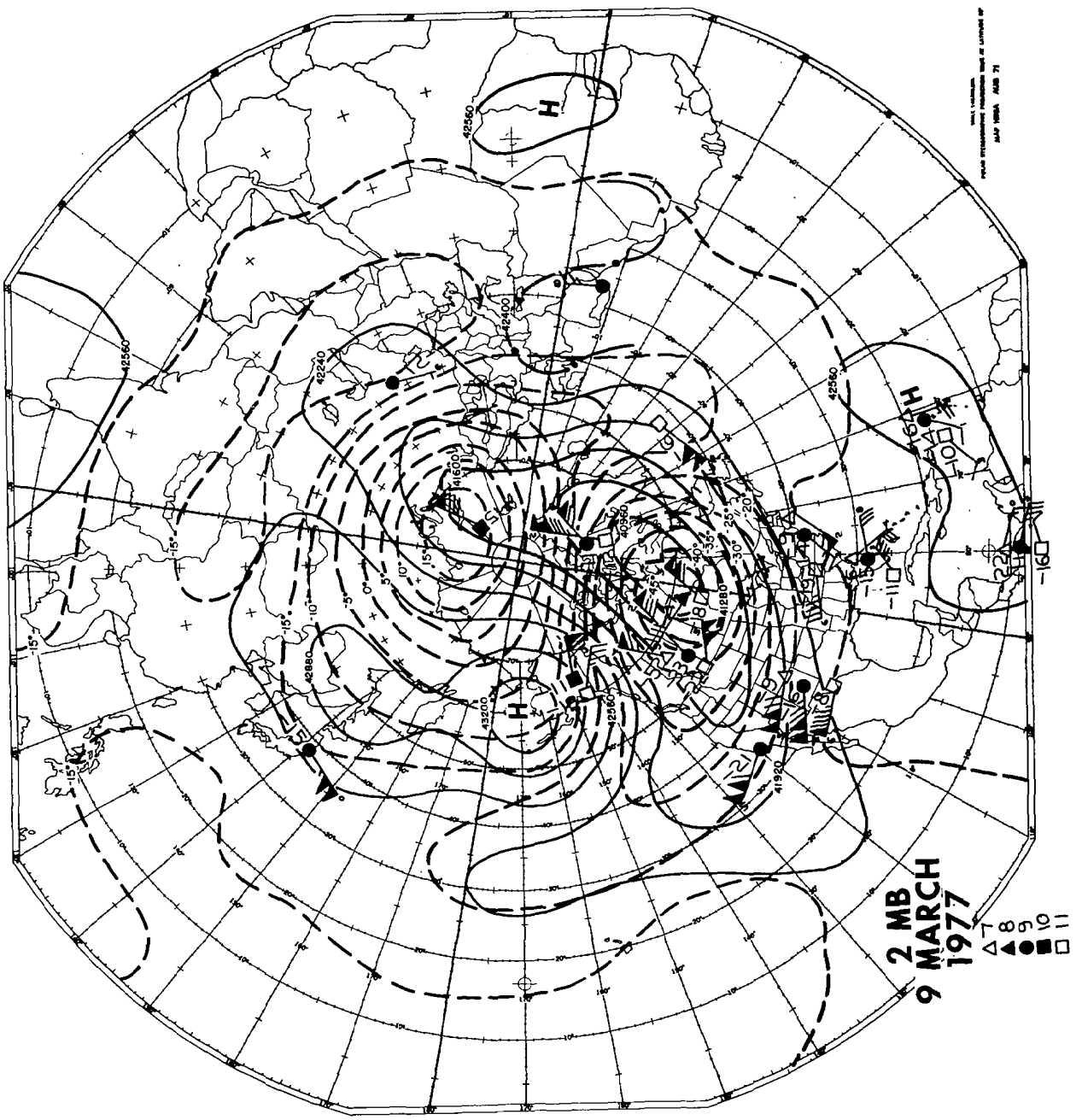
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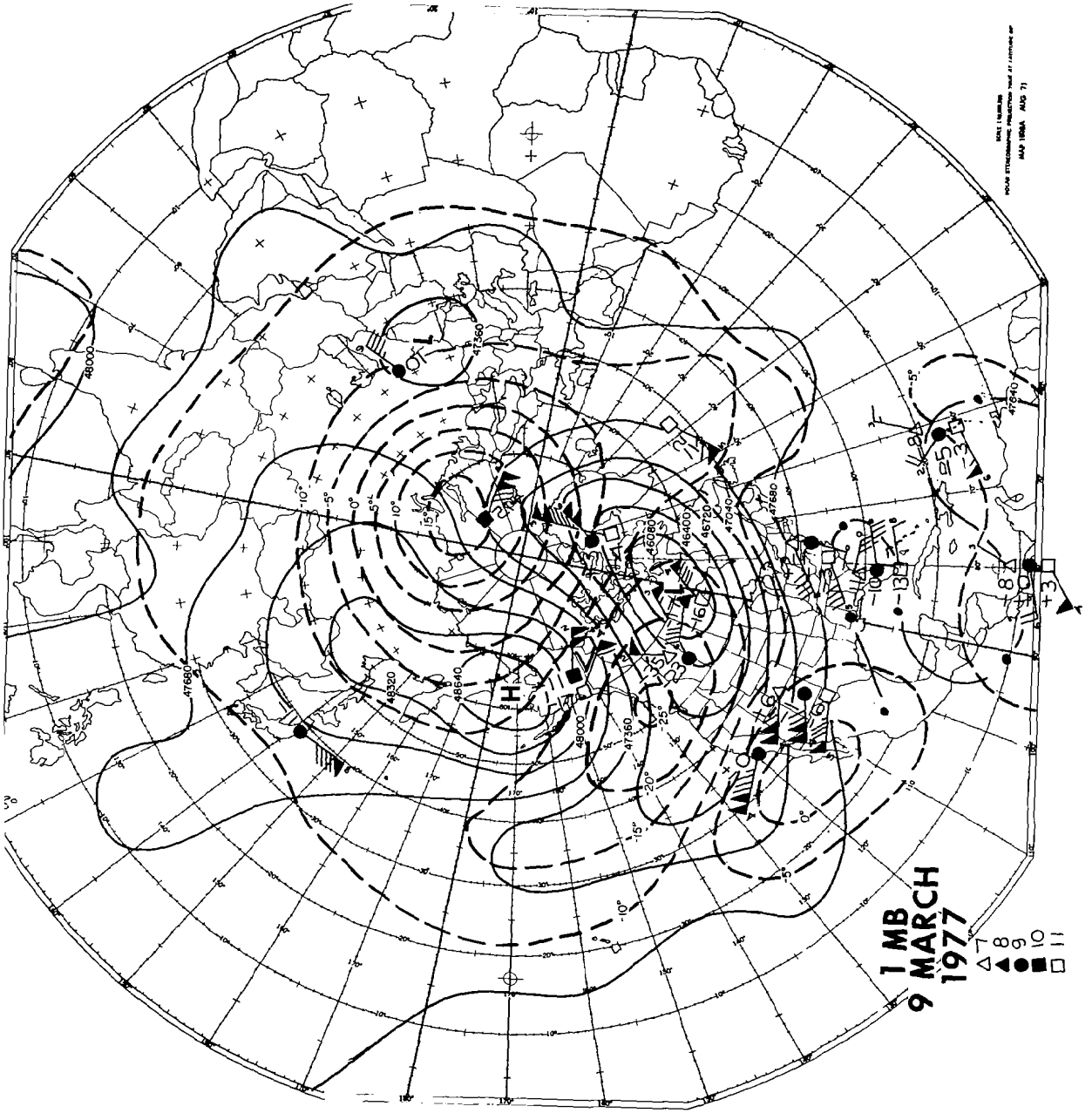
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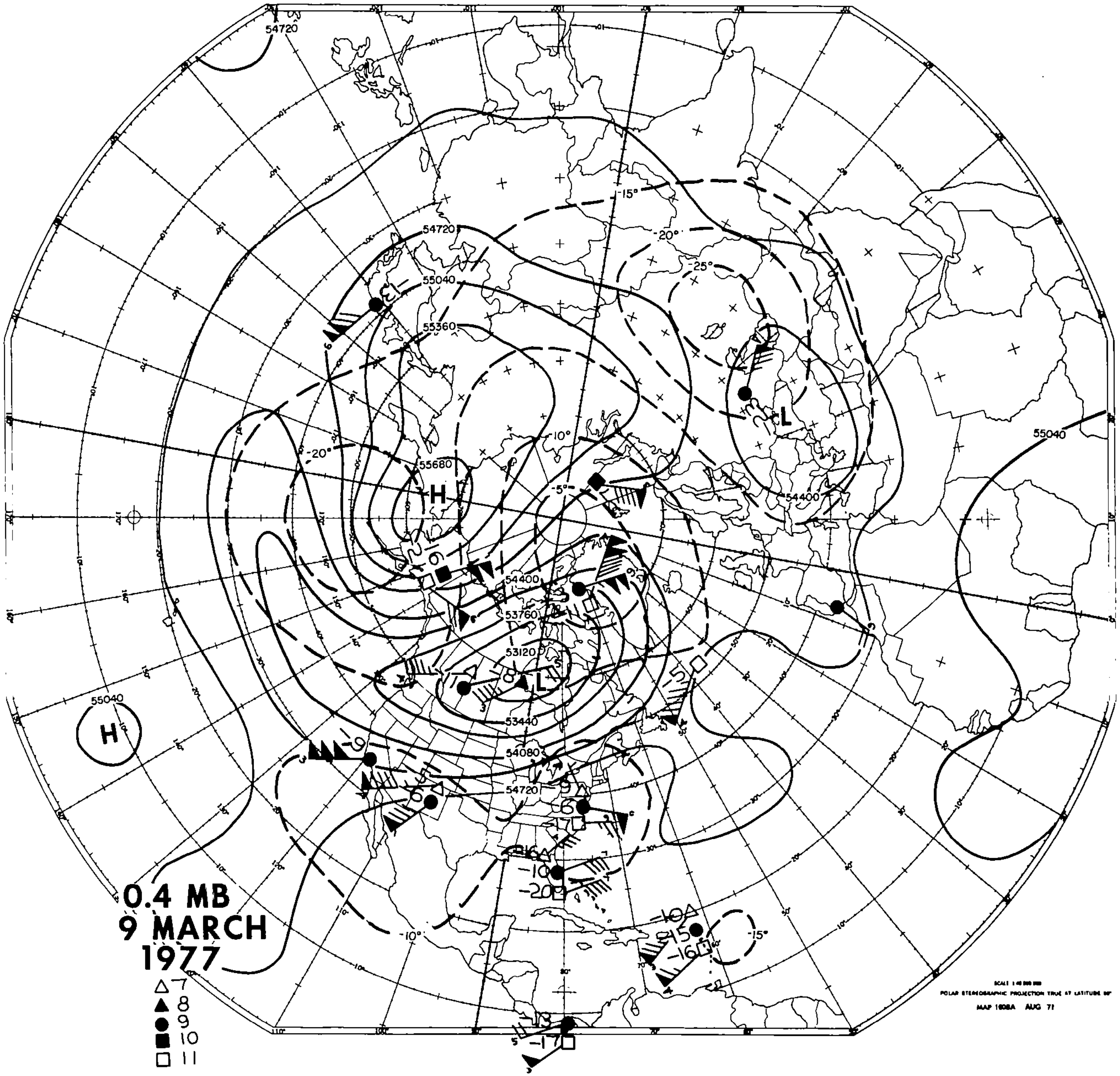
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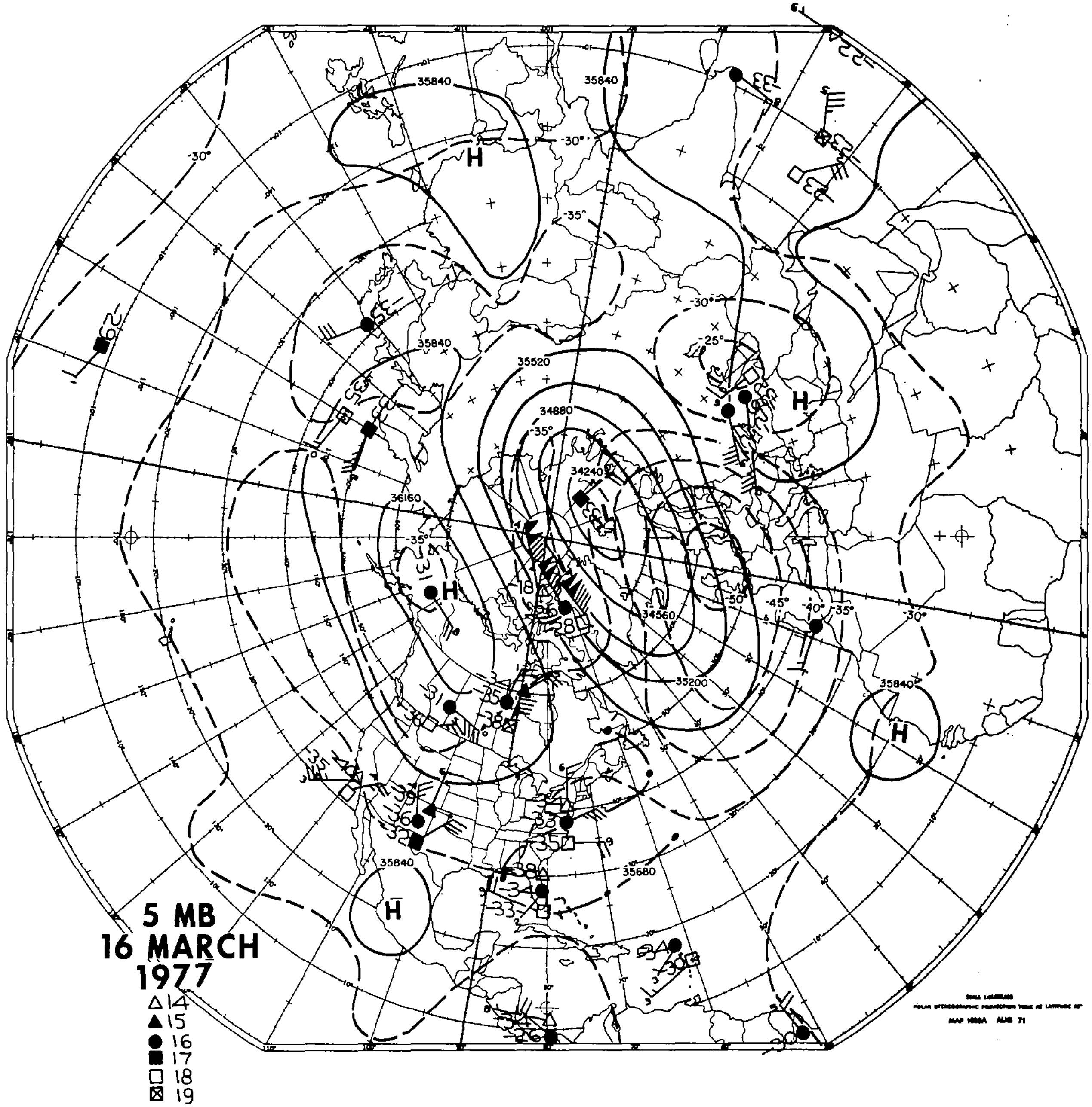
MAP 1608A AUG 71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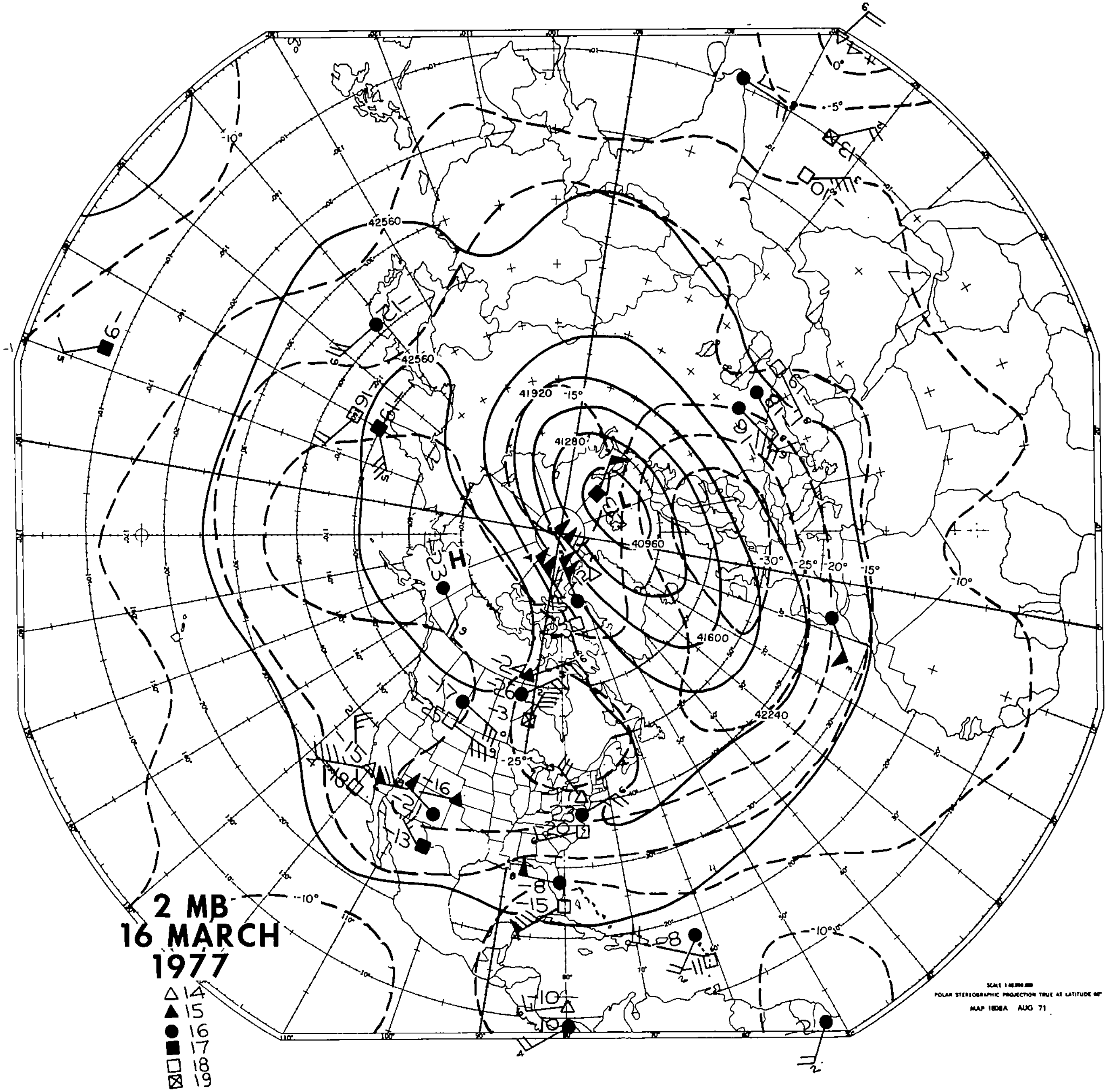
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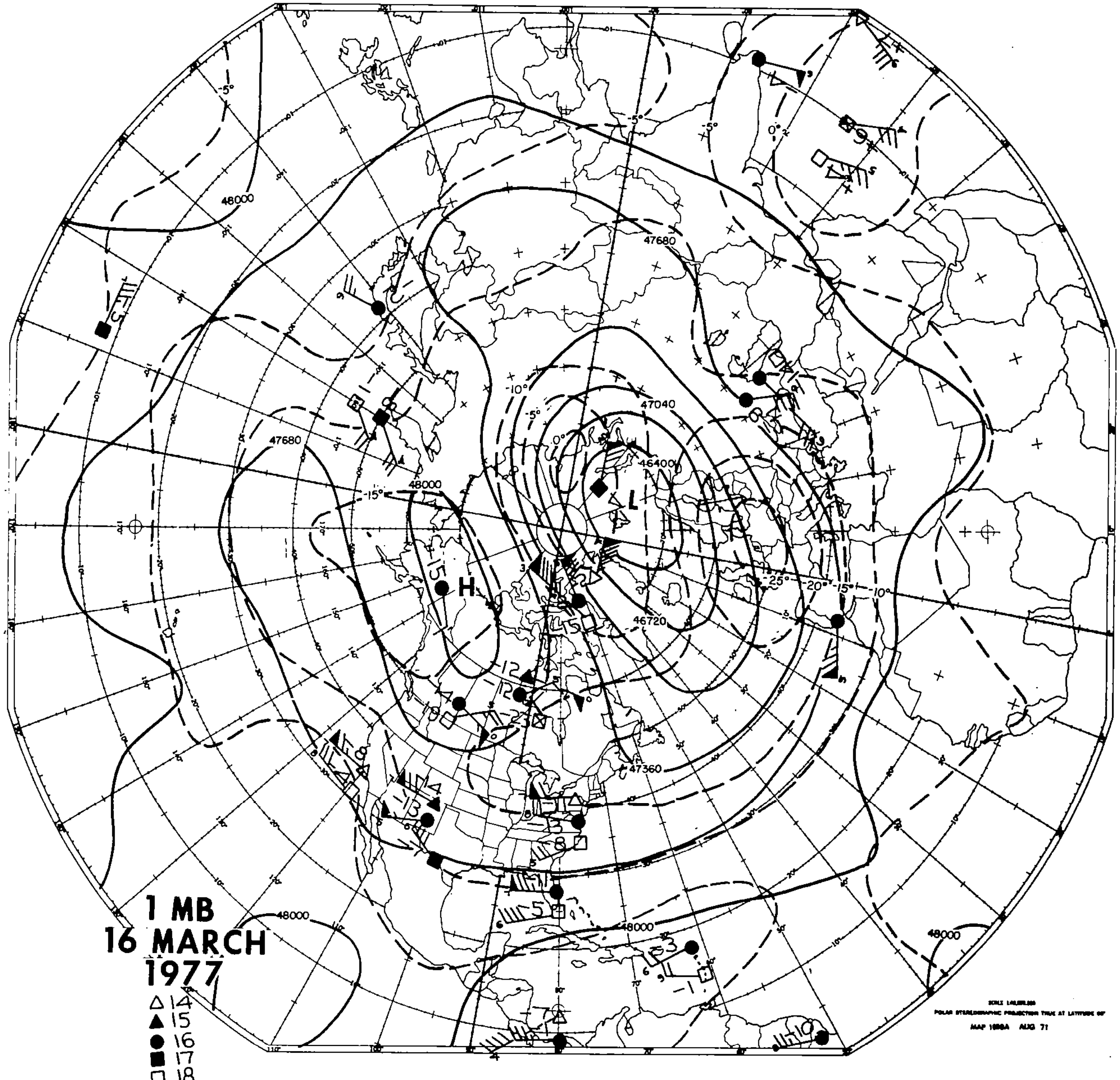
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1808A AUG 71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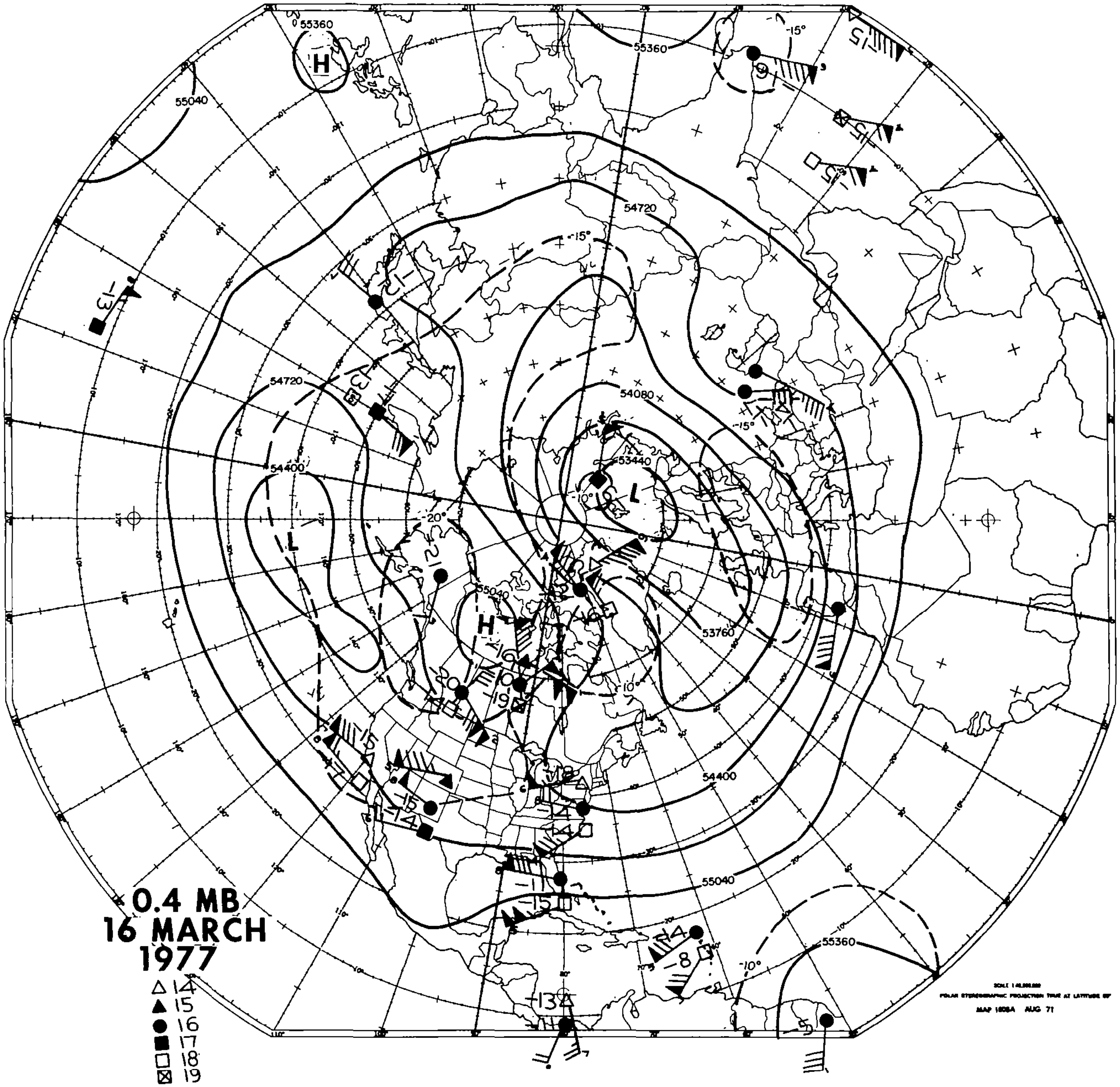
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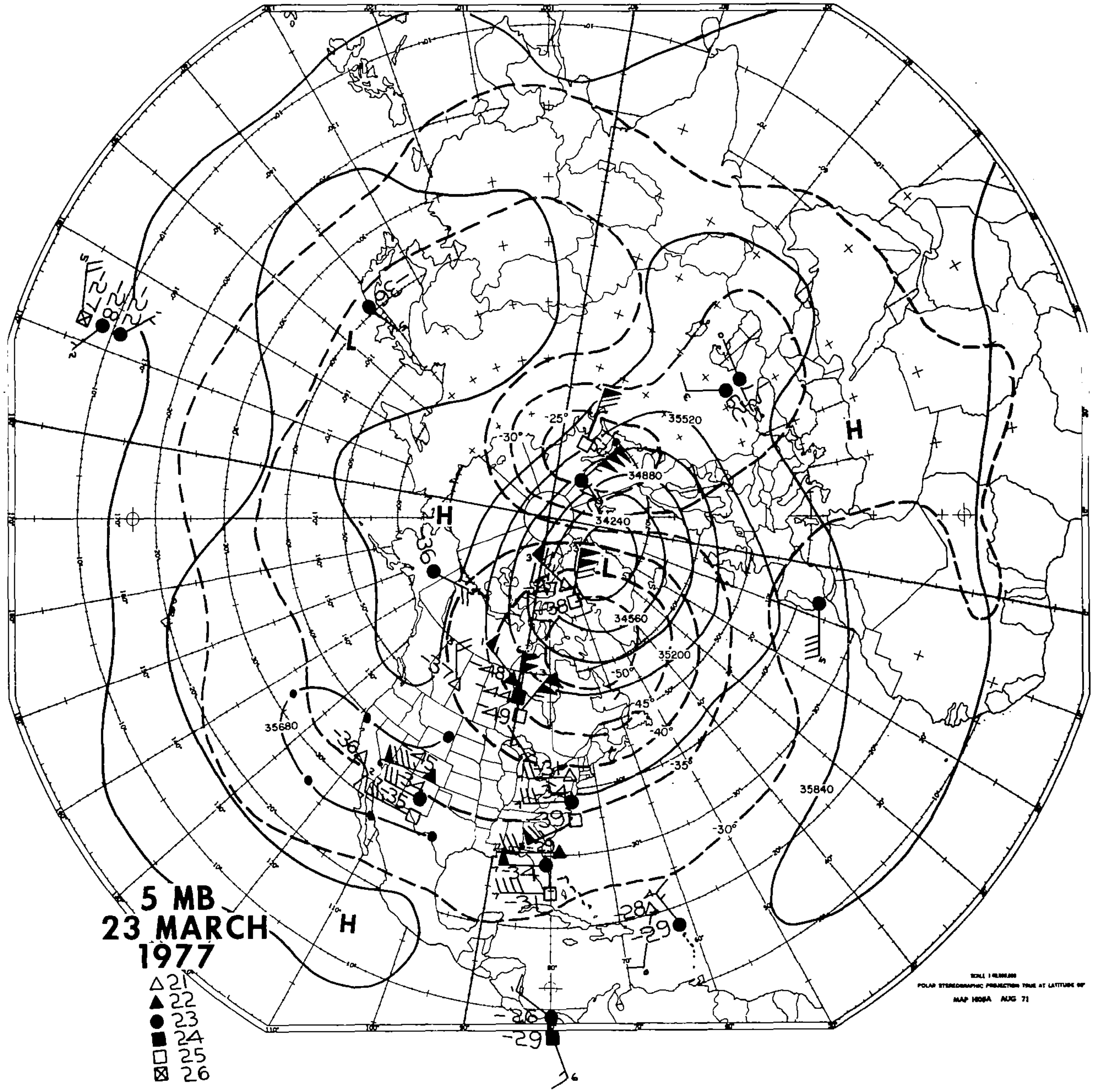
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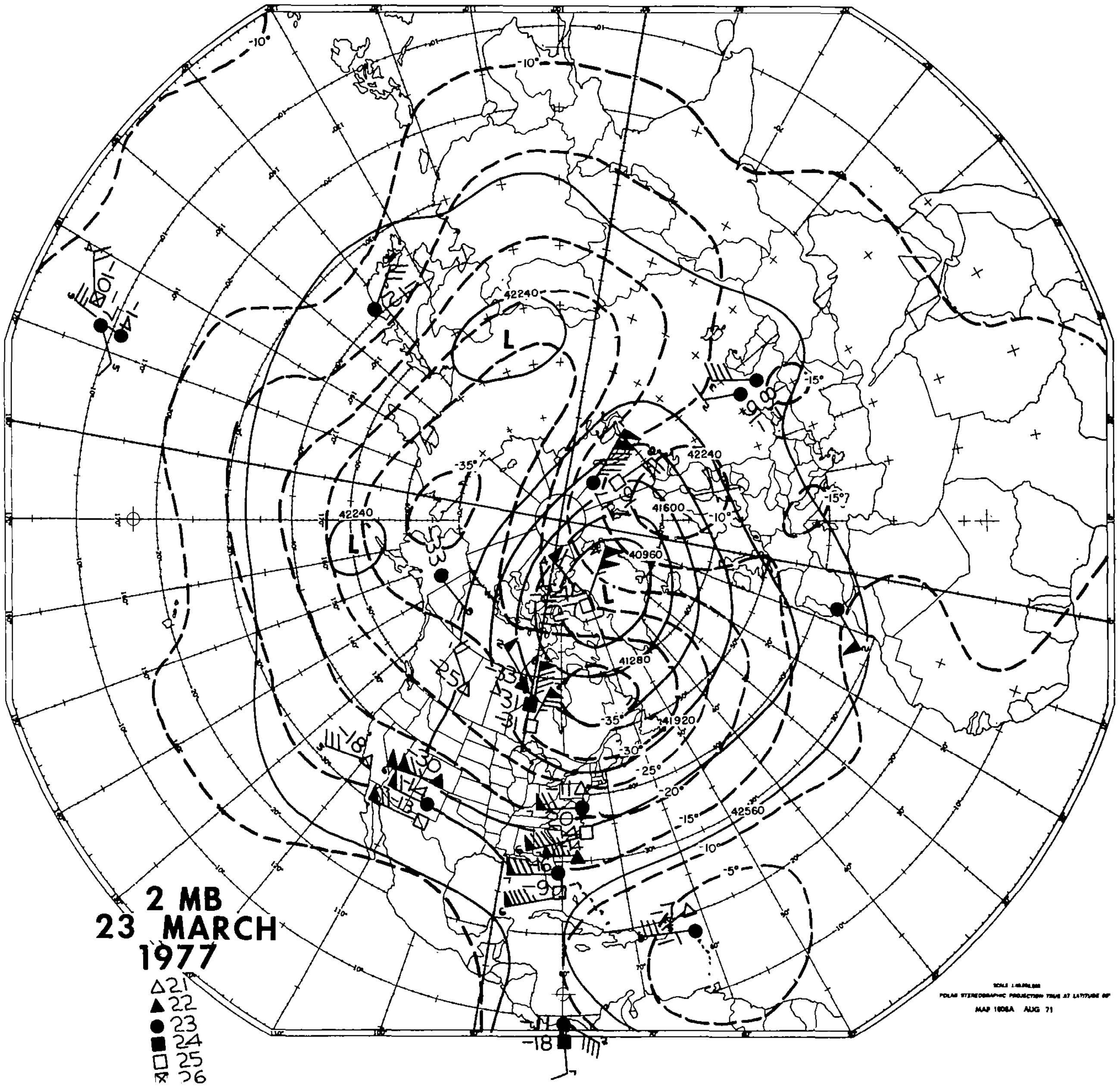
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1108A AUG 71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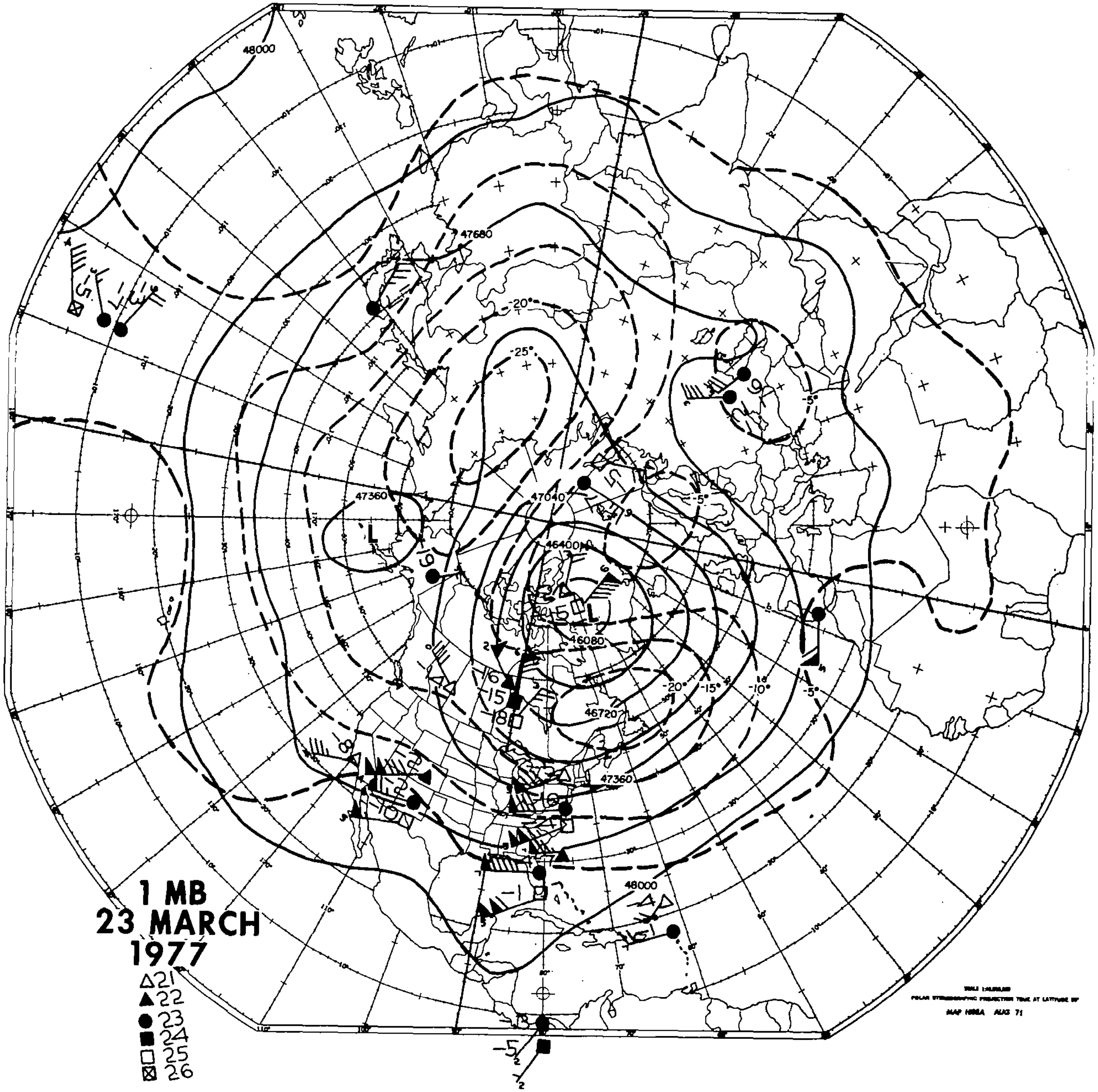

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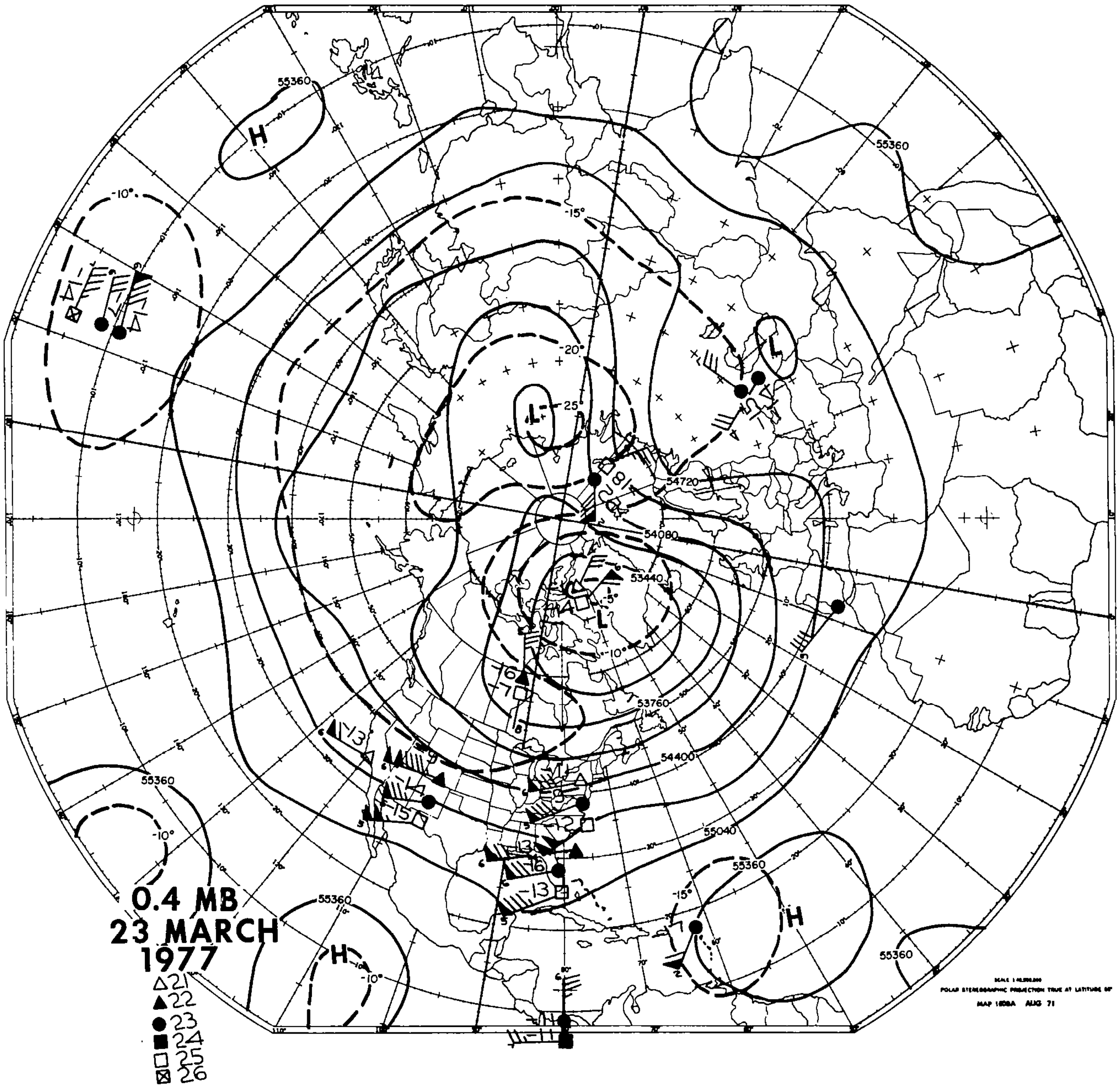
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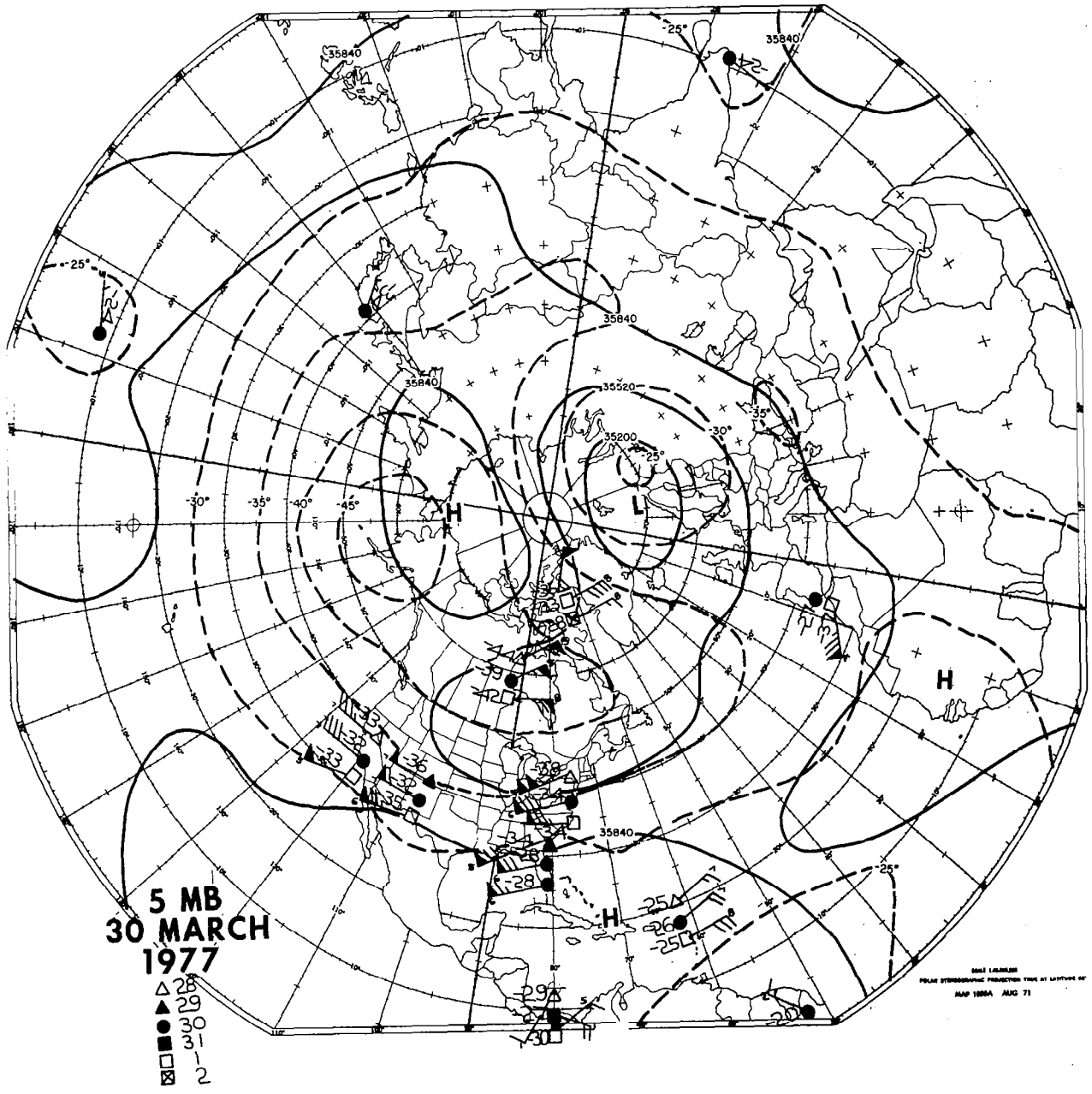
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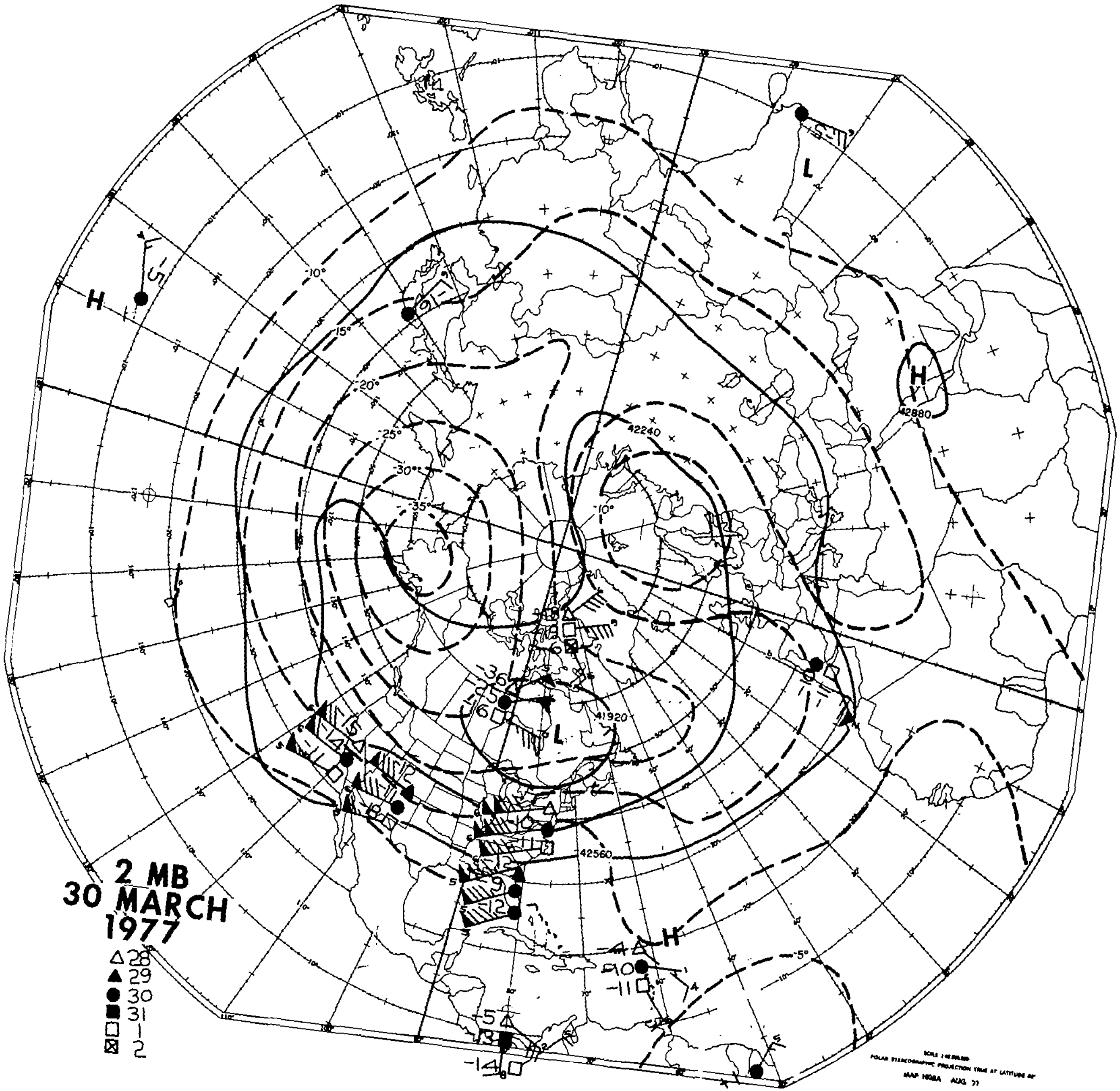
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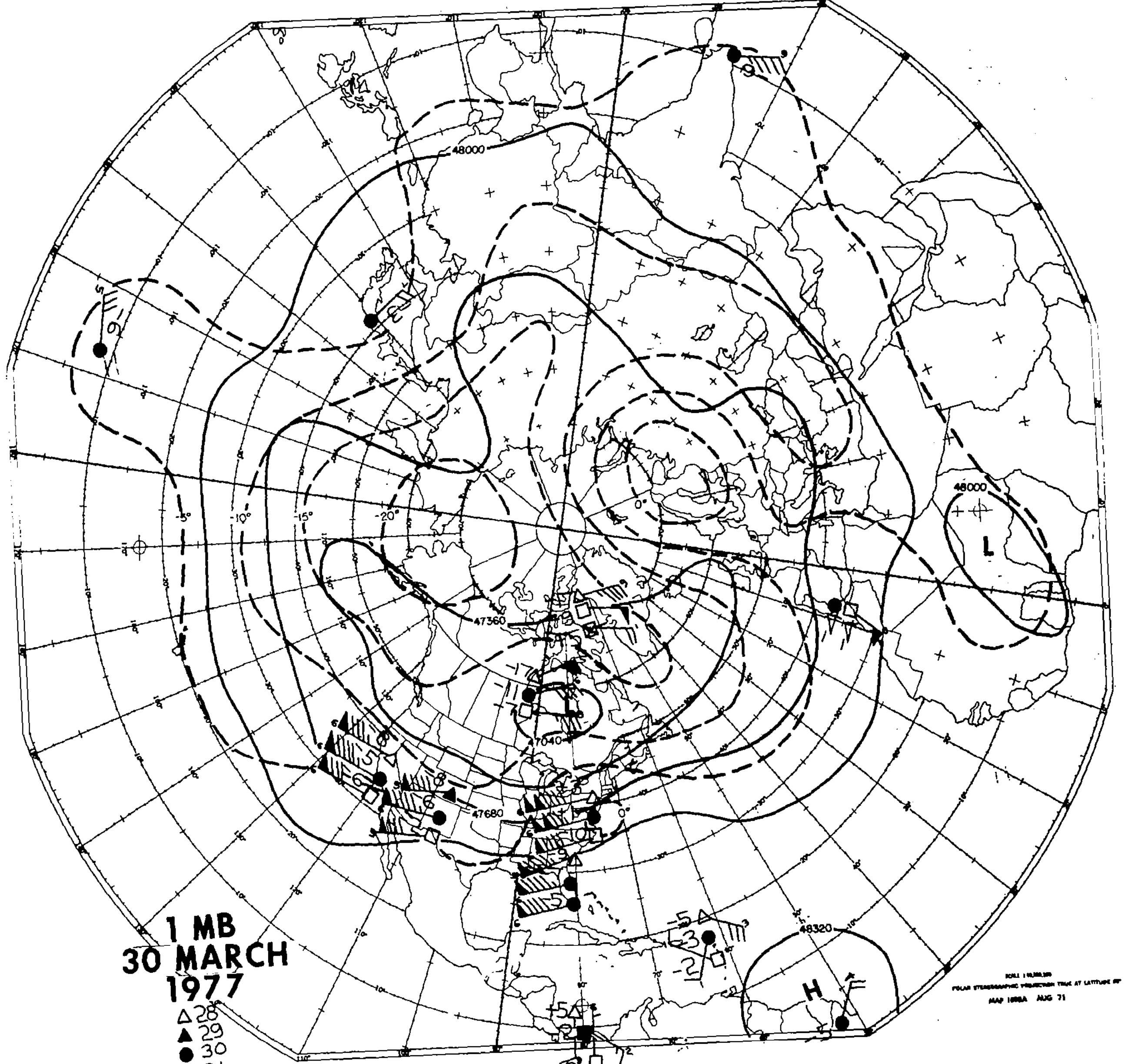

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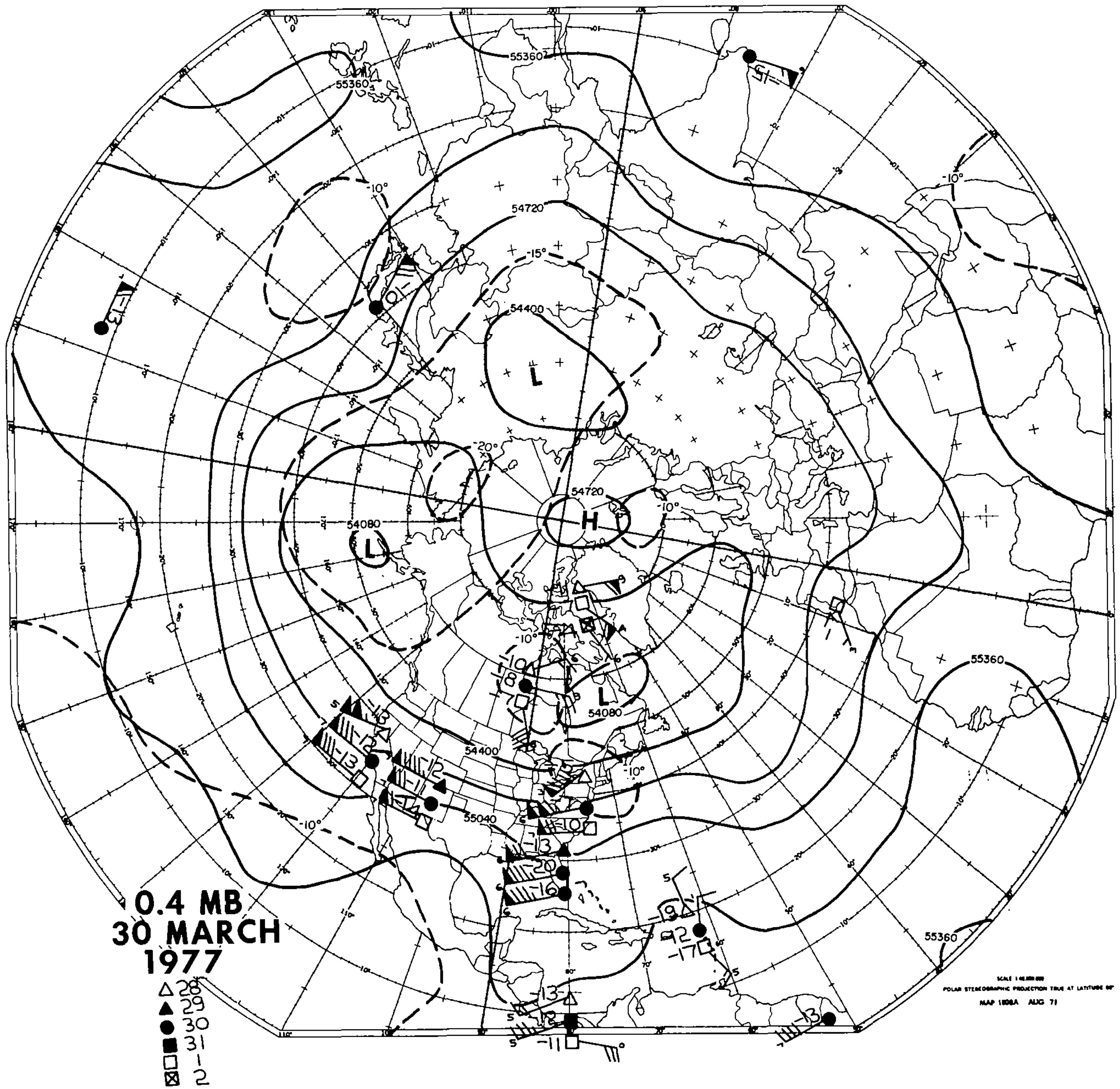
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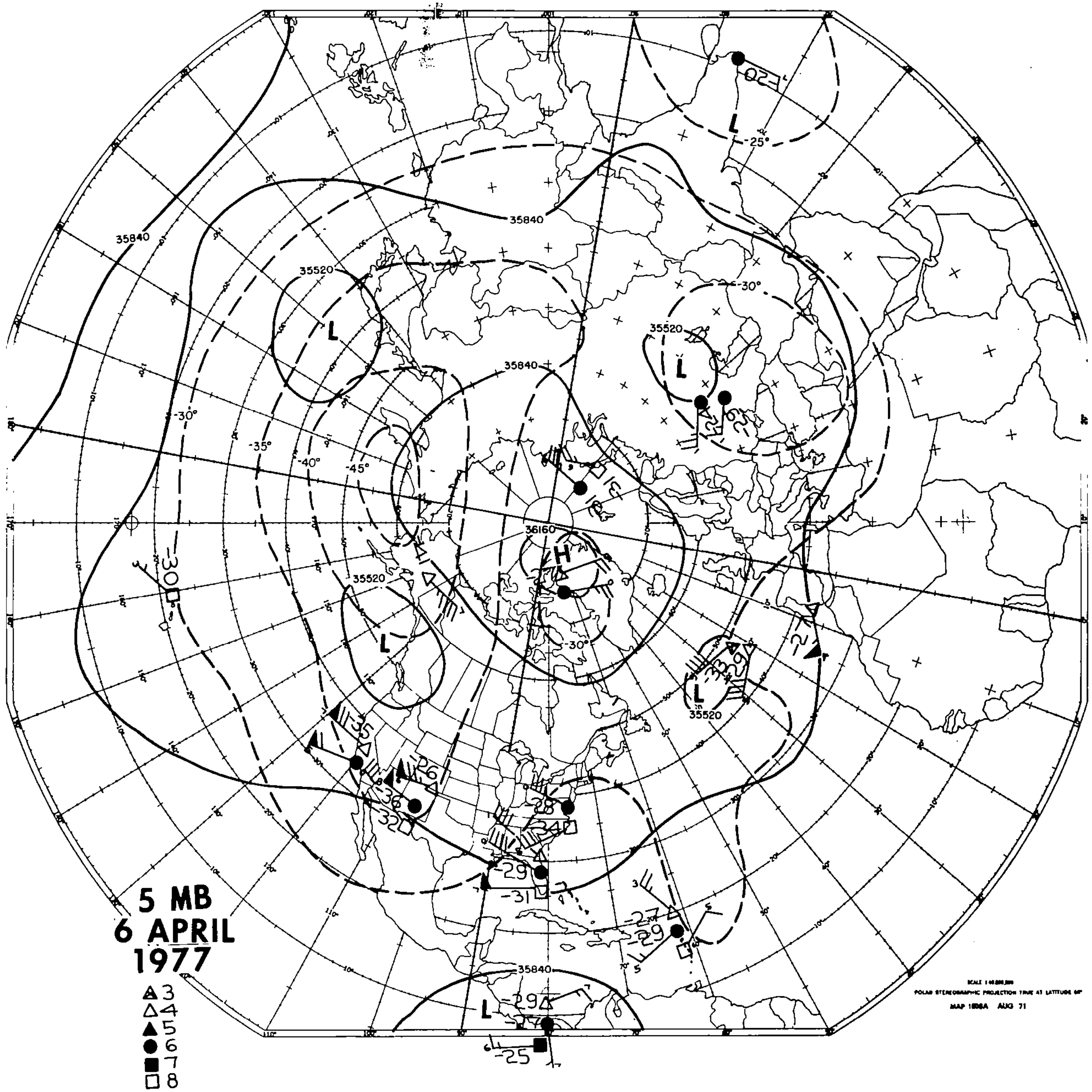
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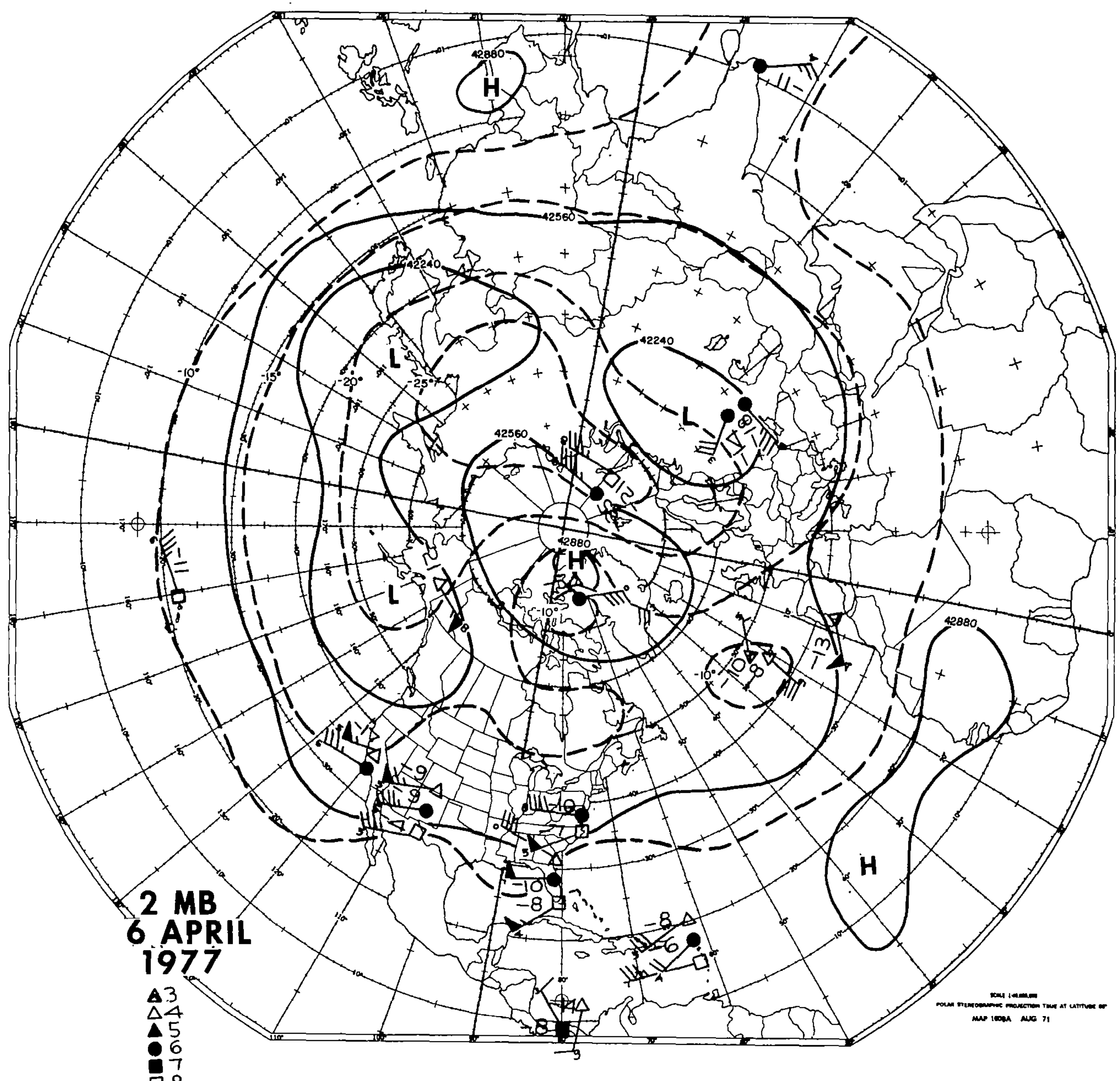
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1808A AUG 71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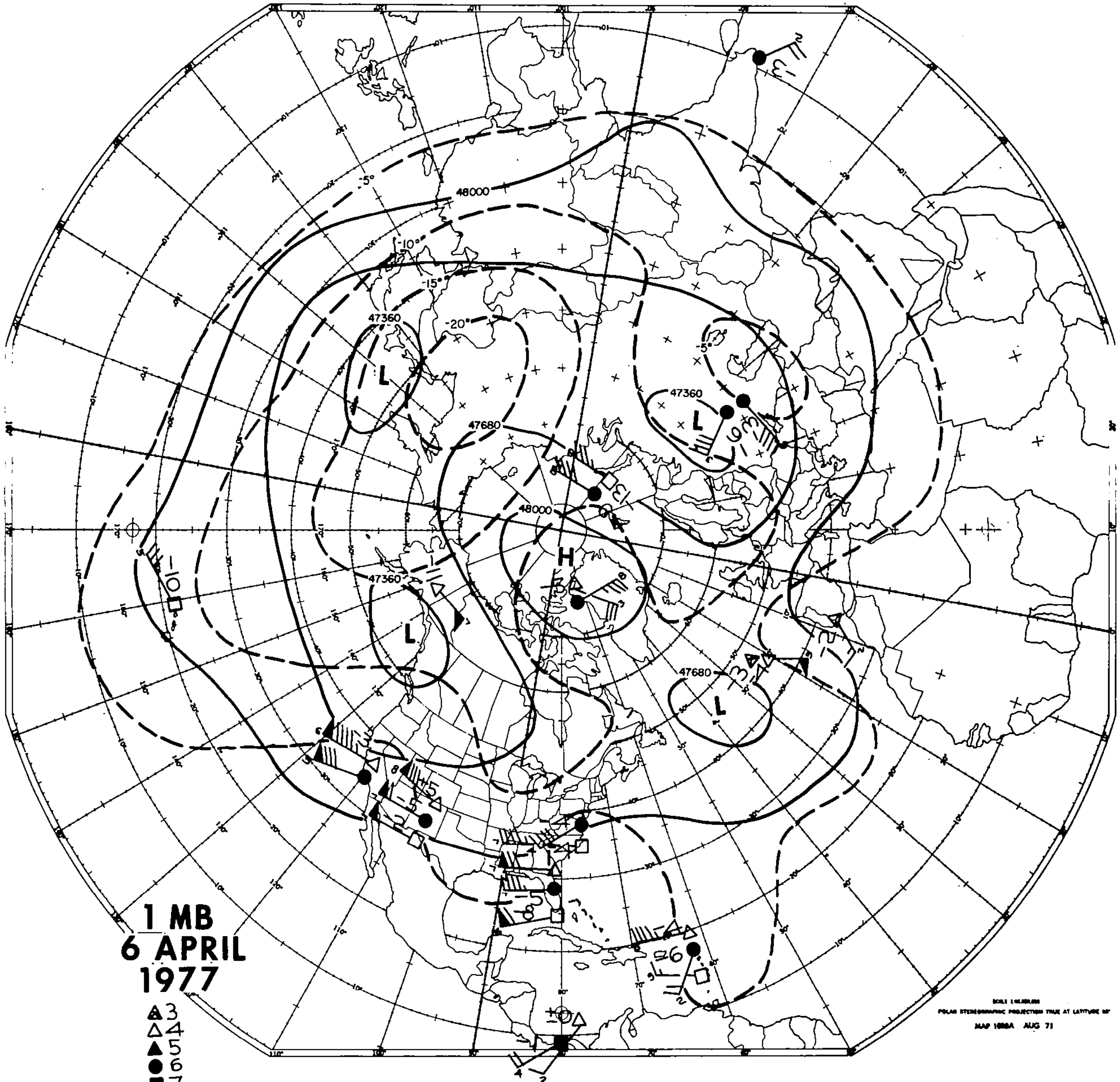

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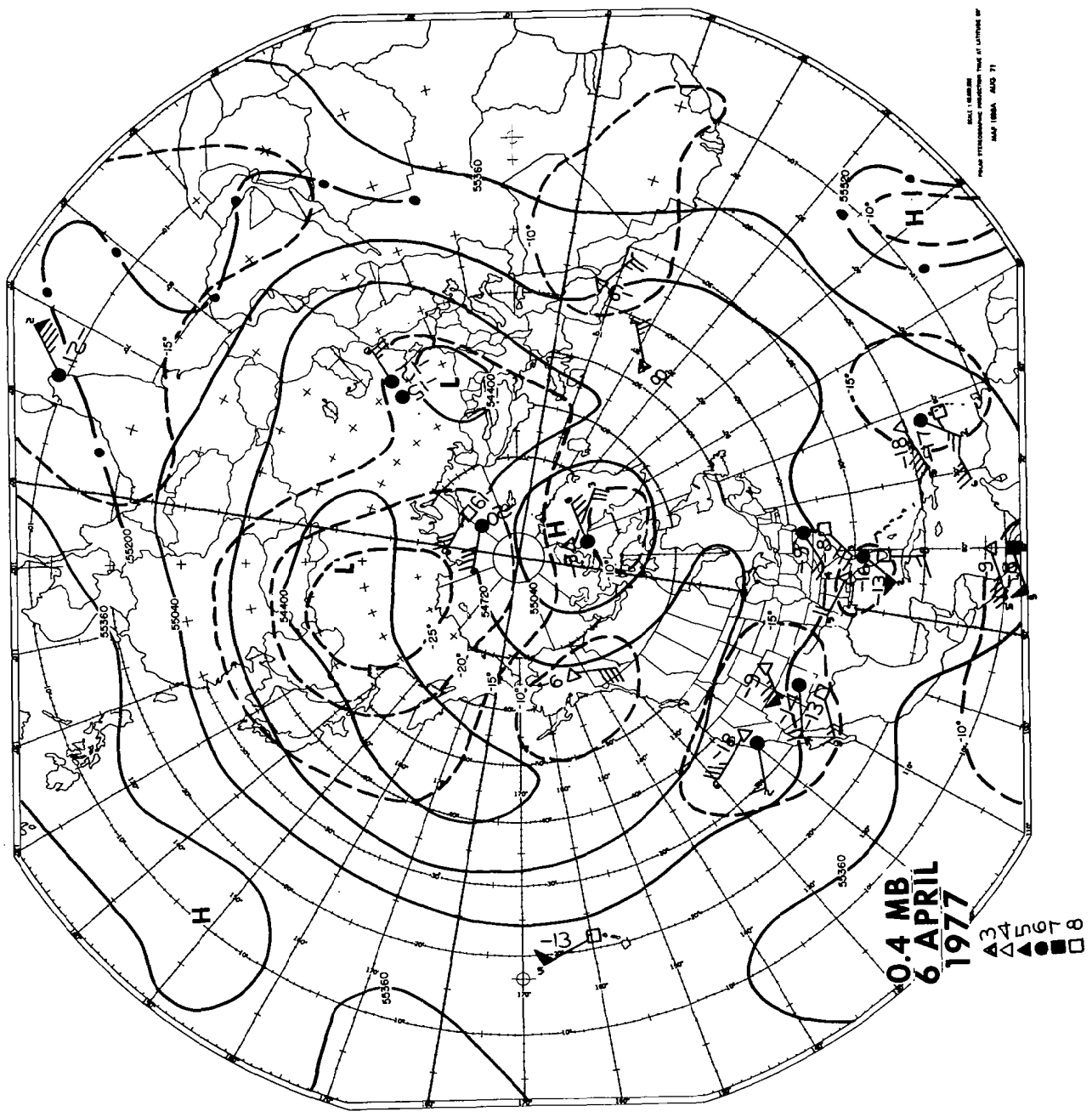
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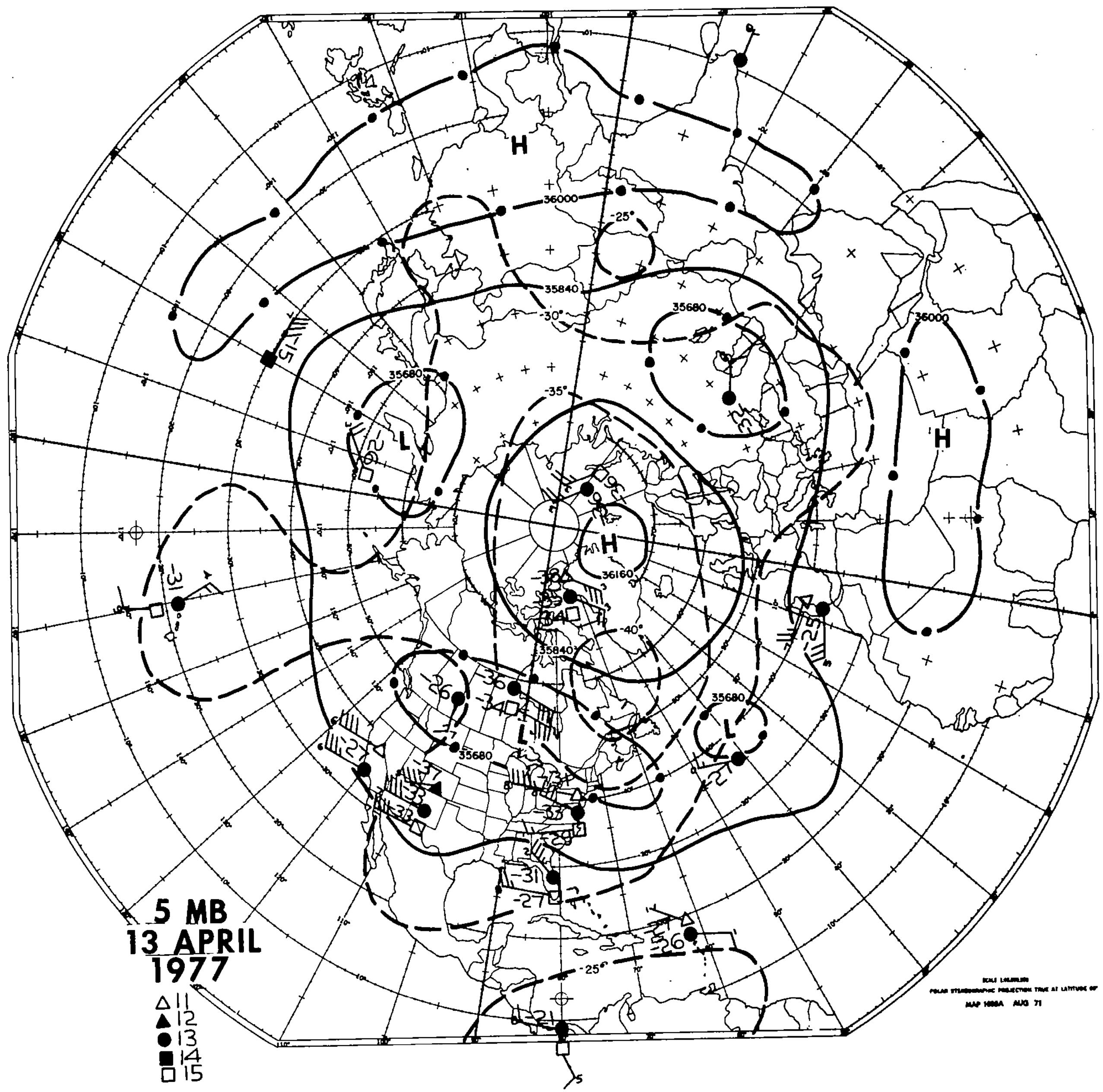

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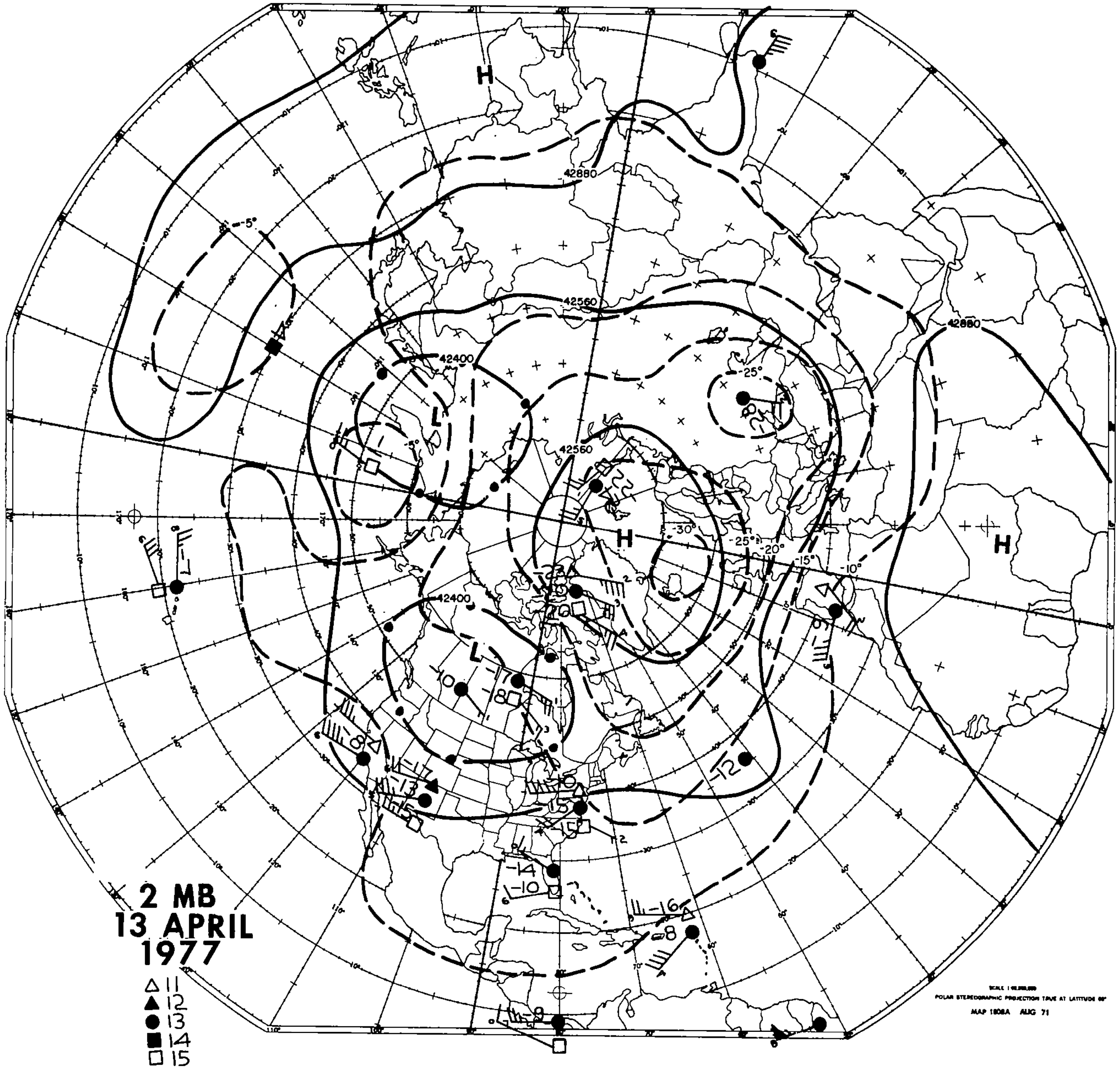

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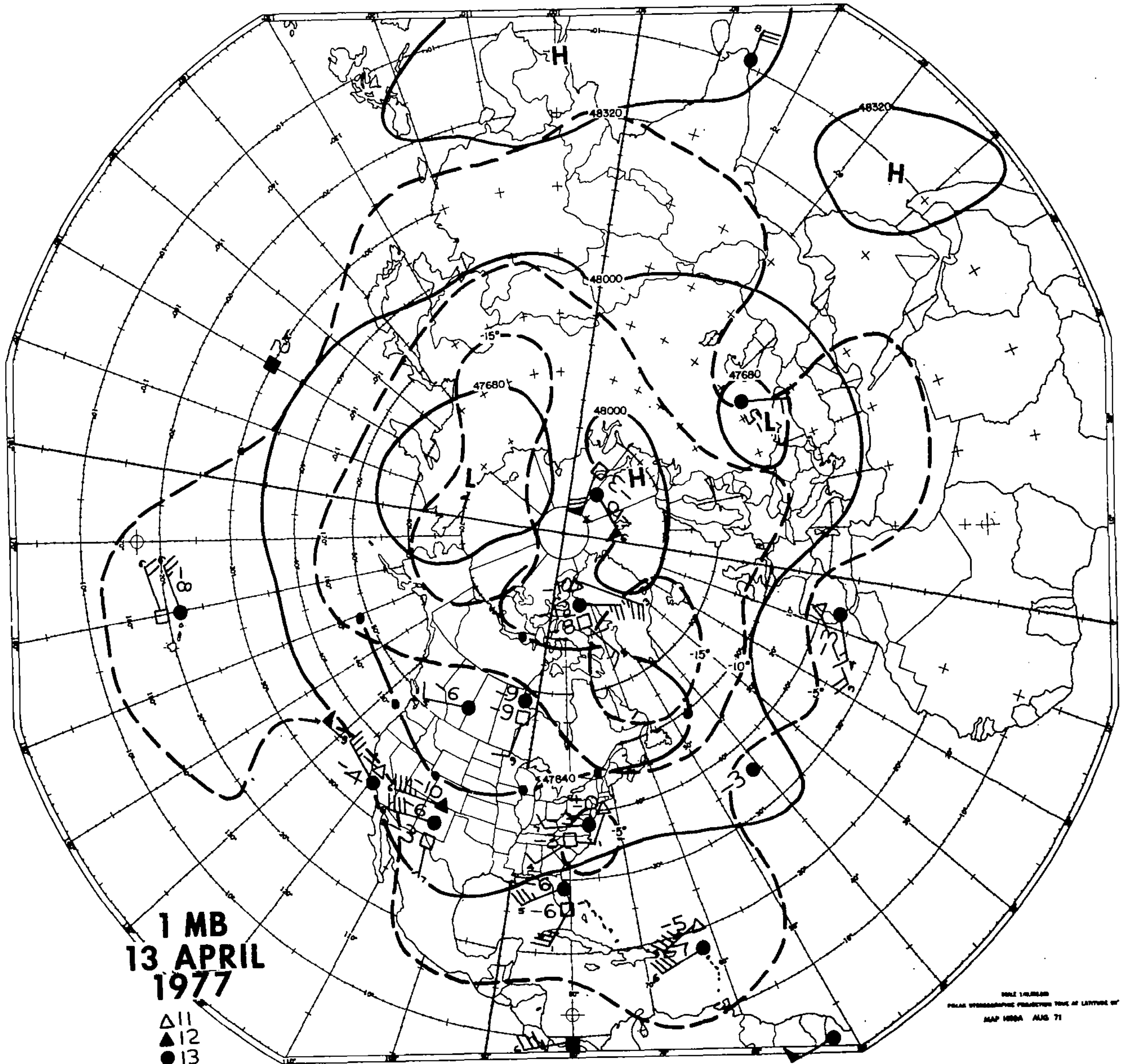

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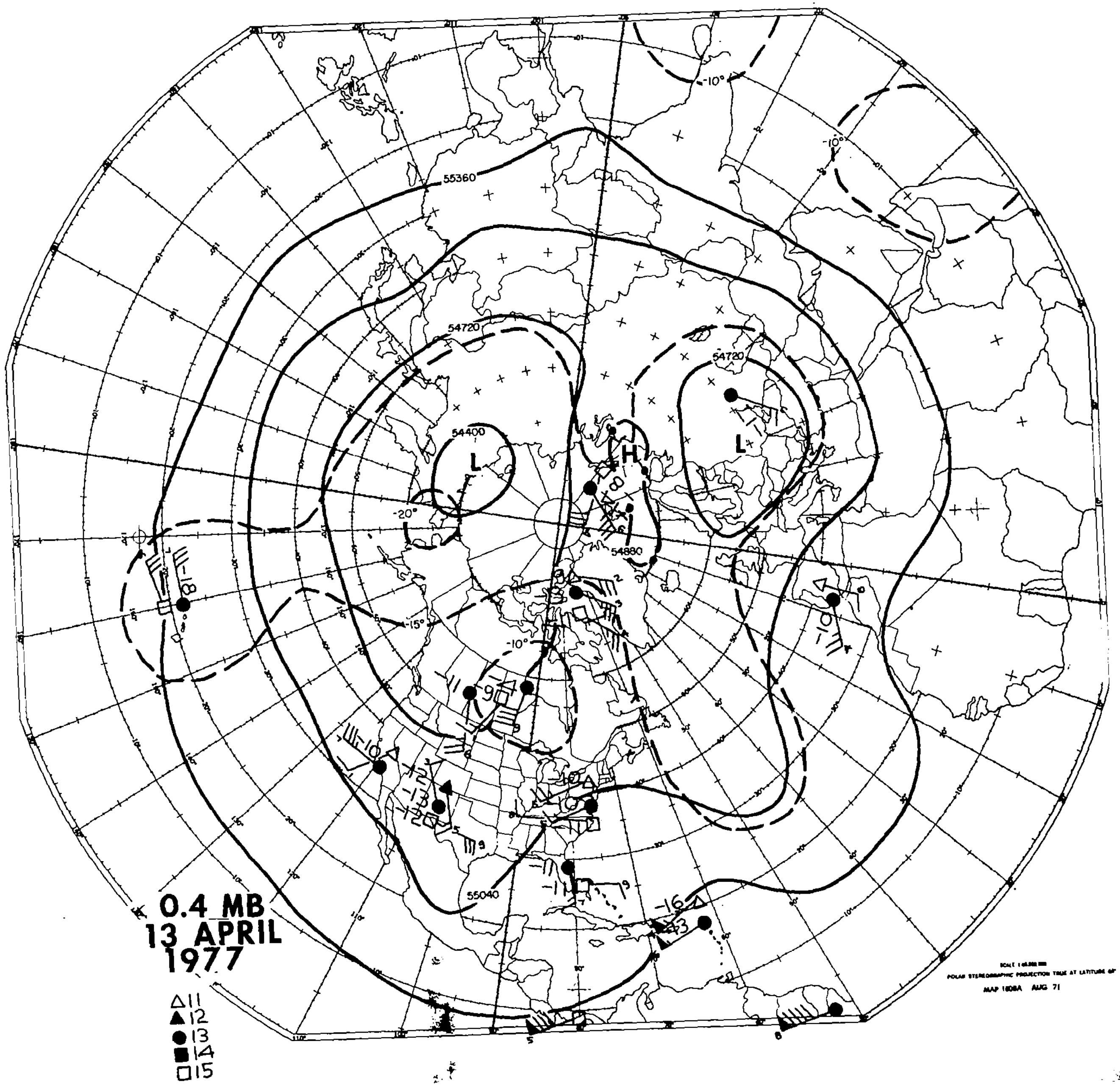

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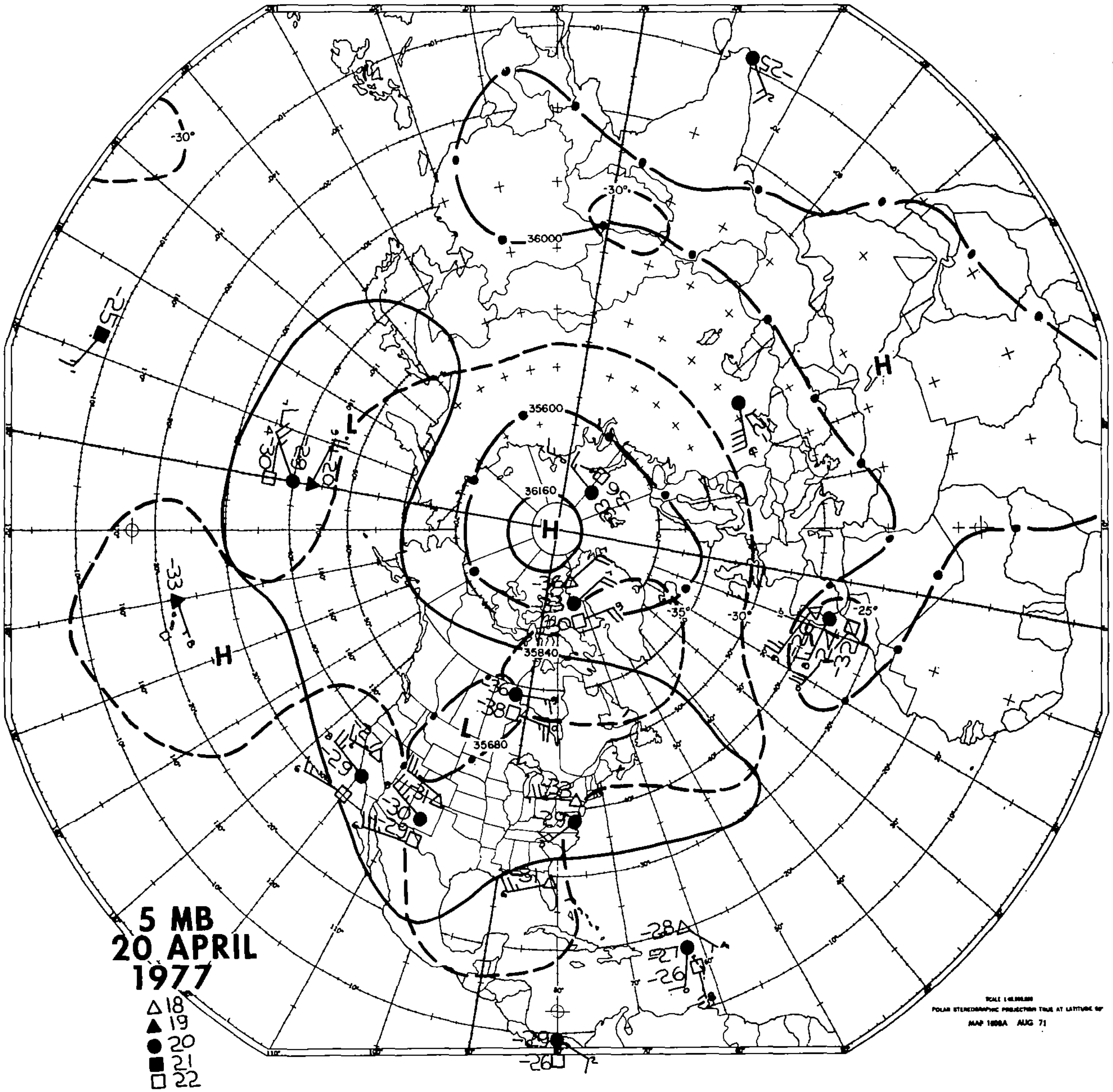
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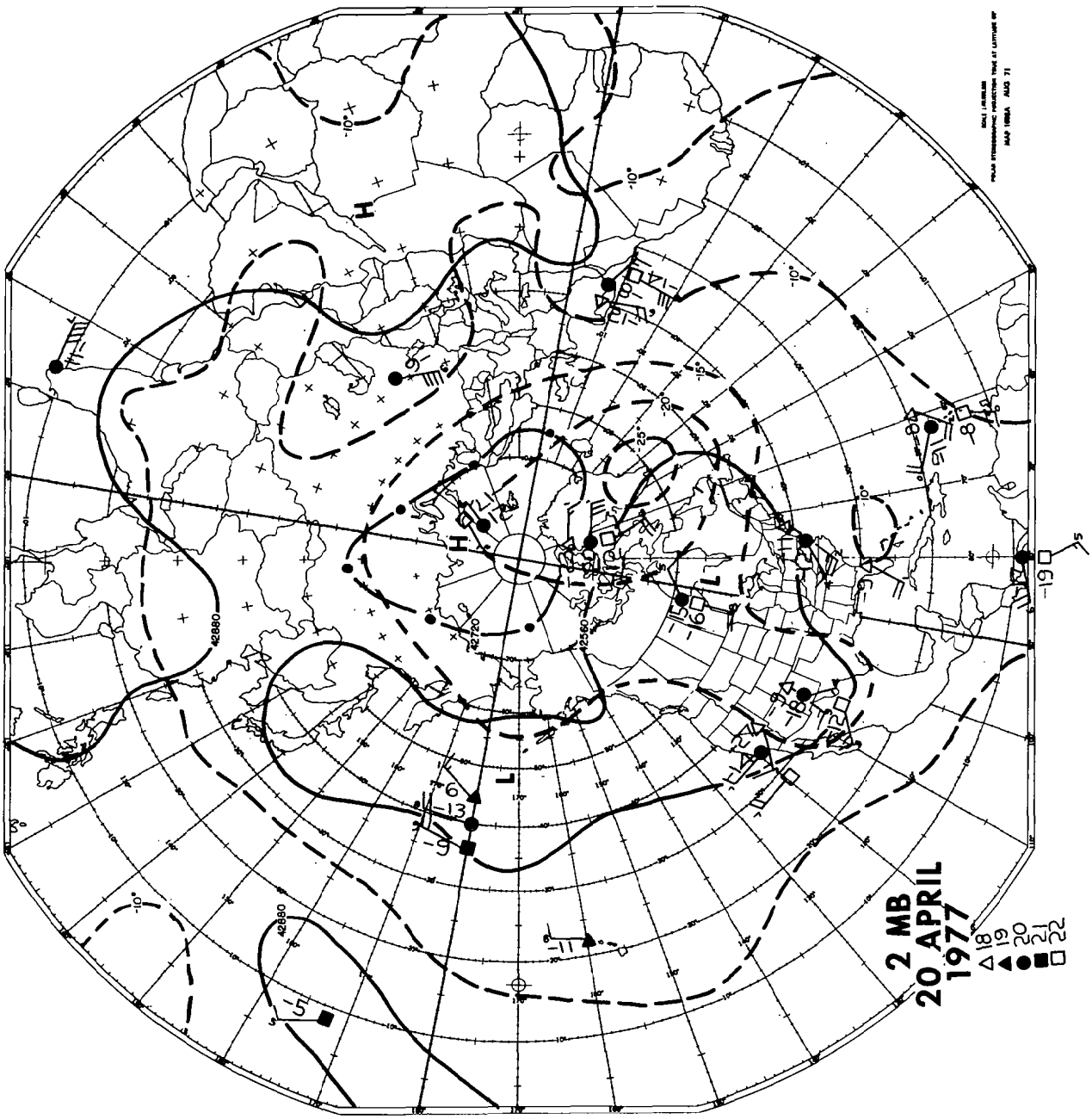
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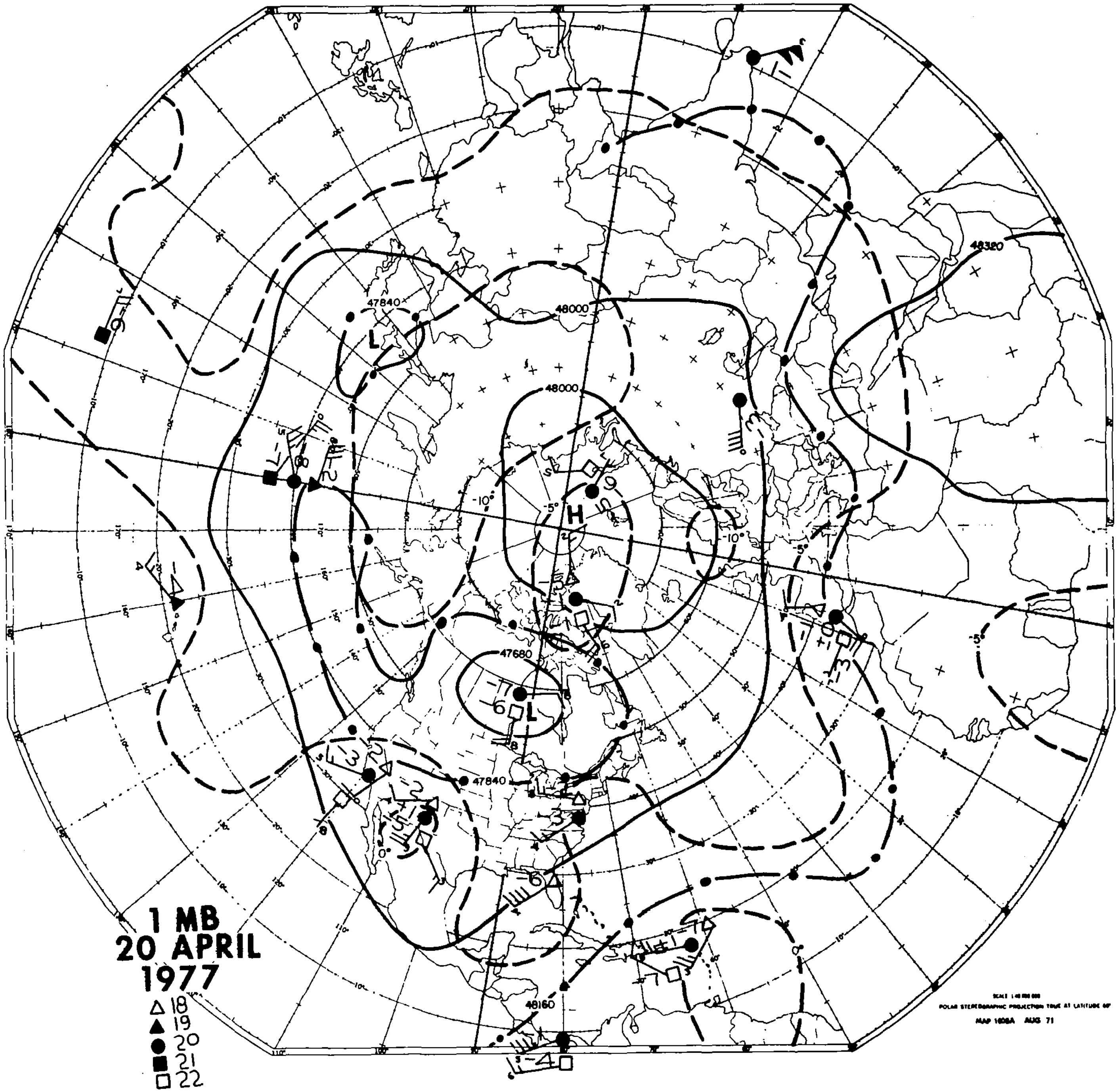
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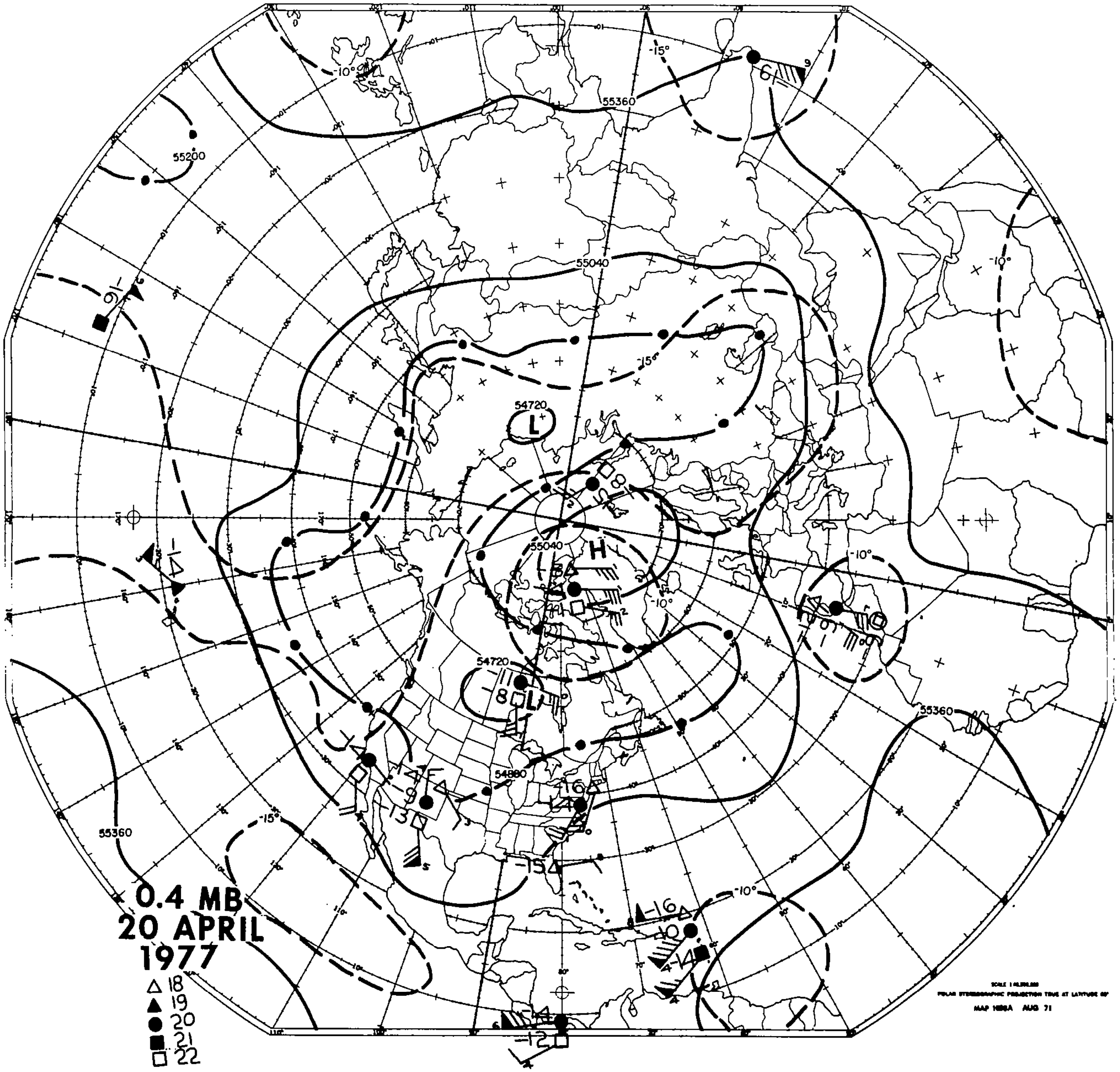
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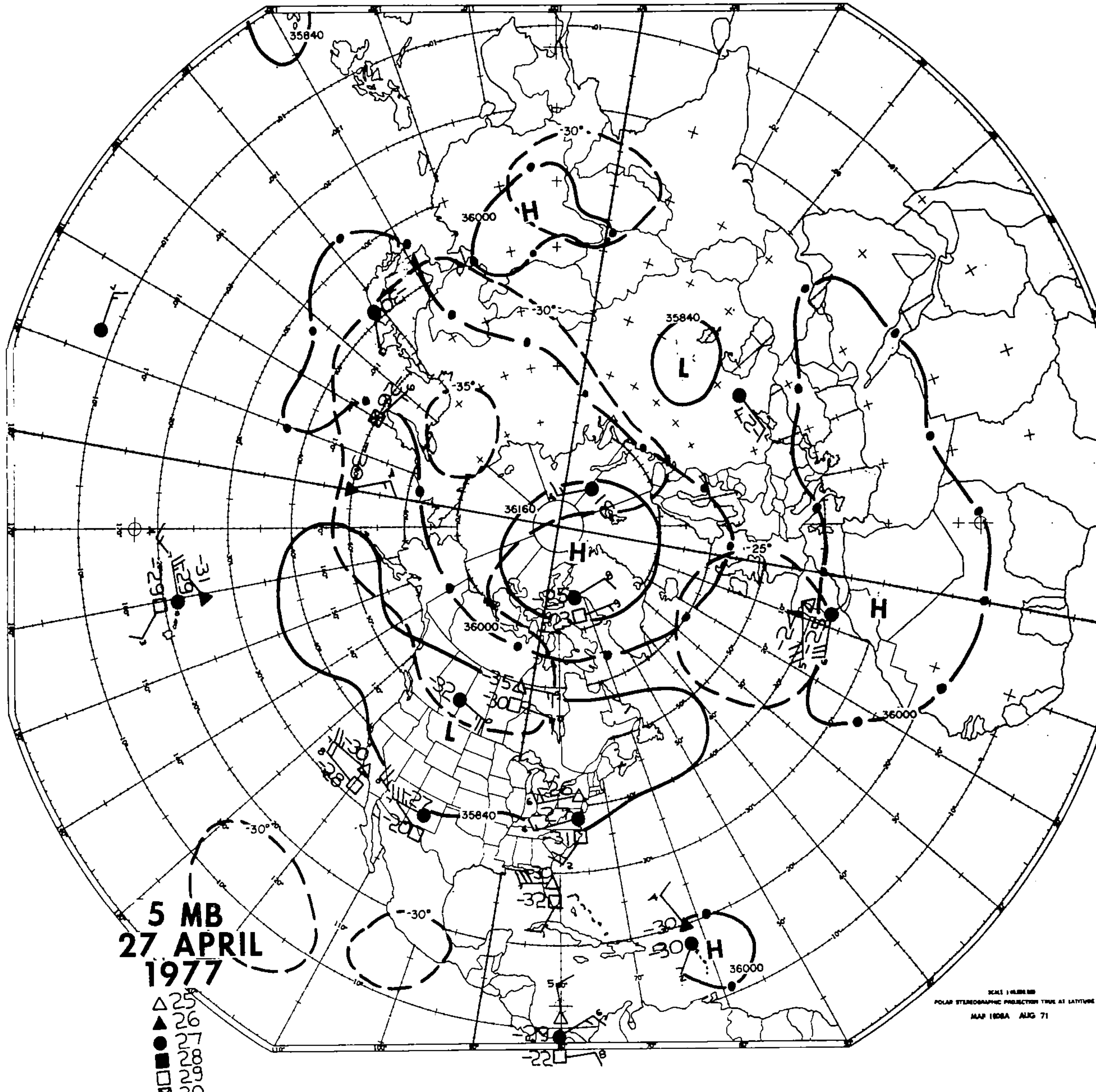
-15°
MAP 1108A AUG 71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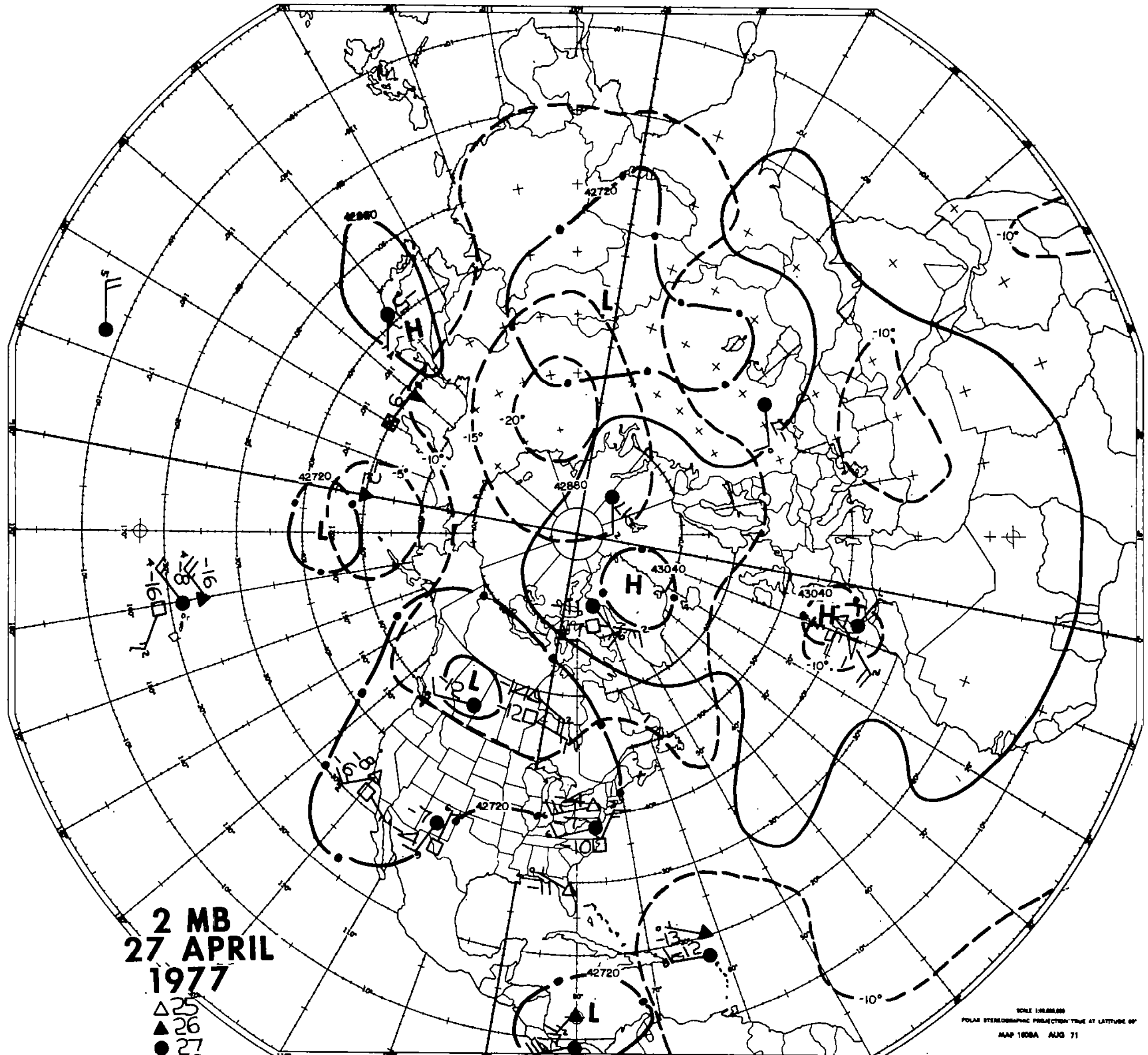

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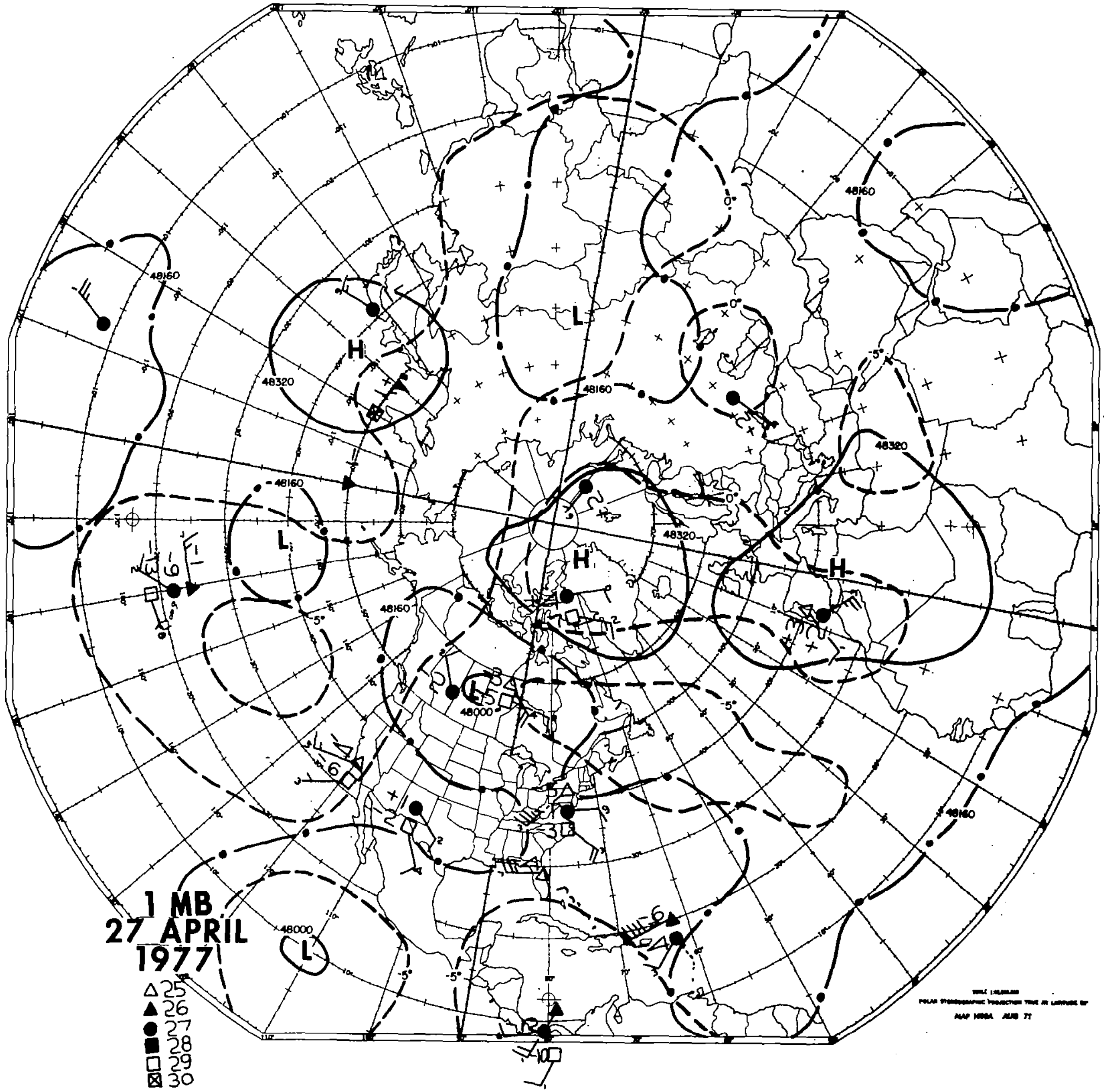
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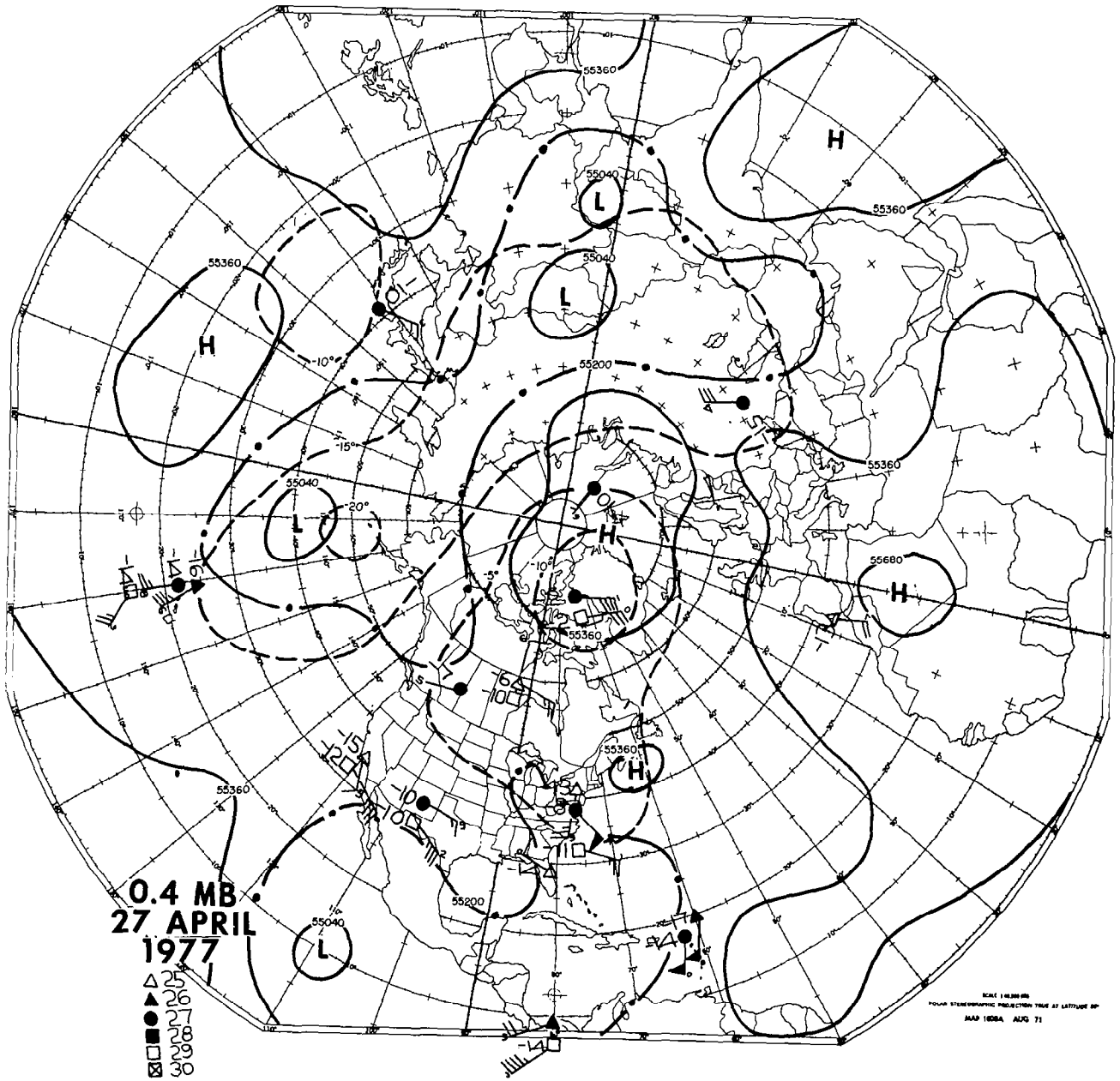
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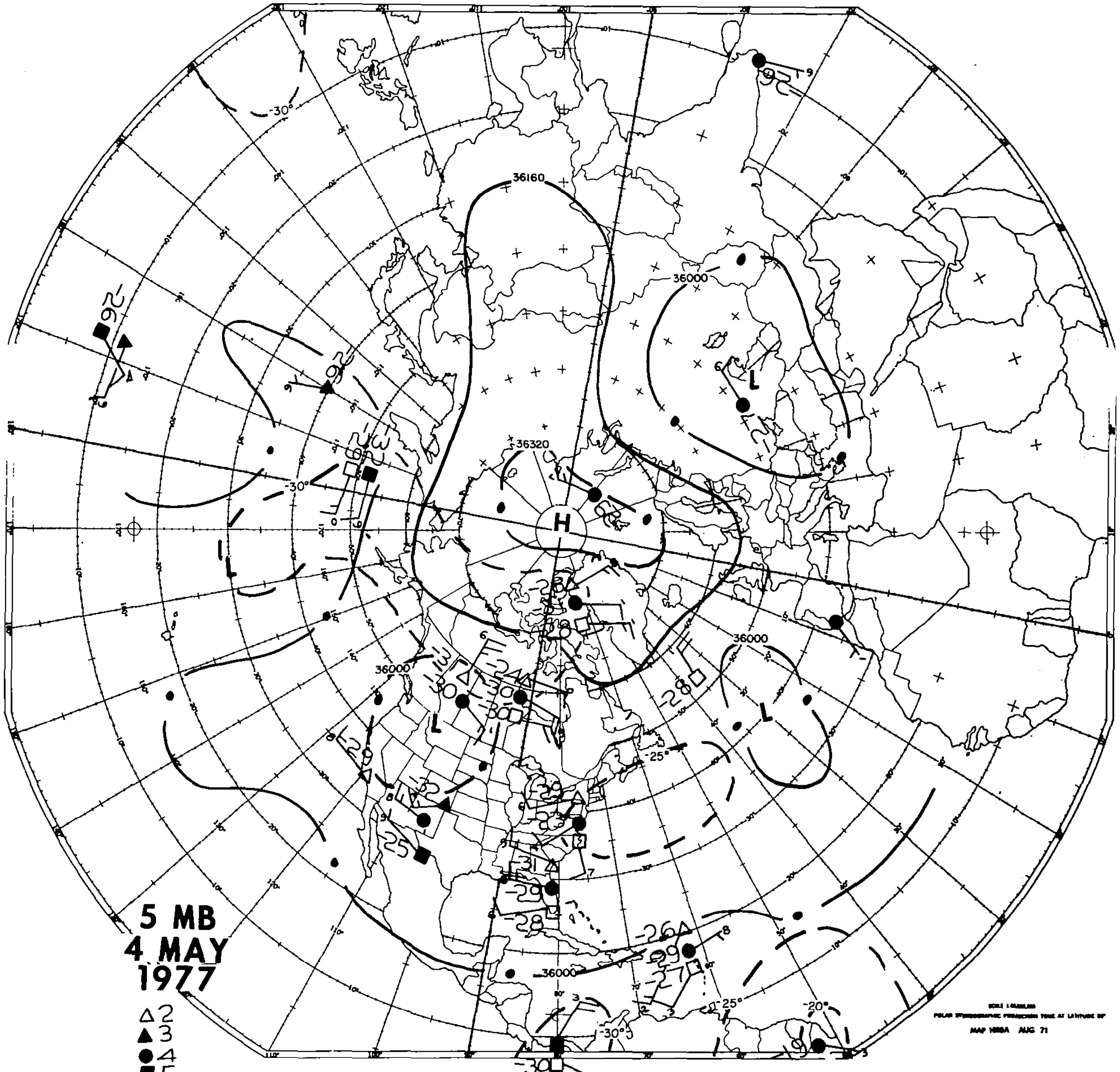
MAP 1608A AUG 71



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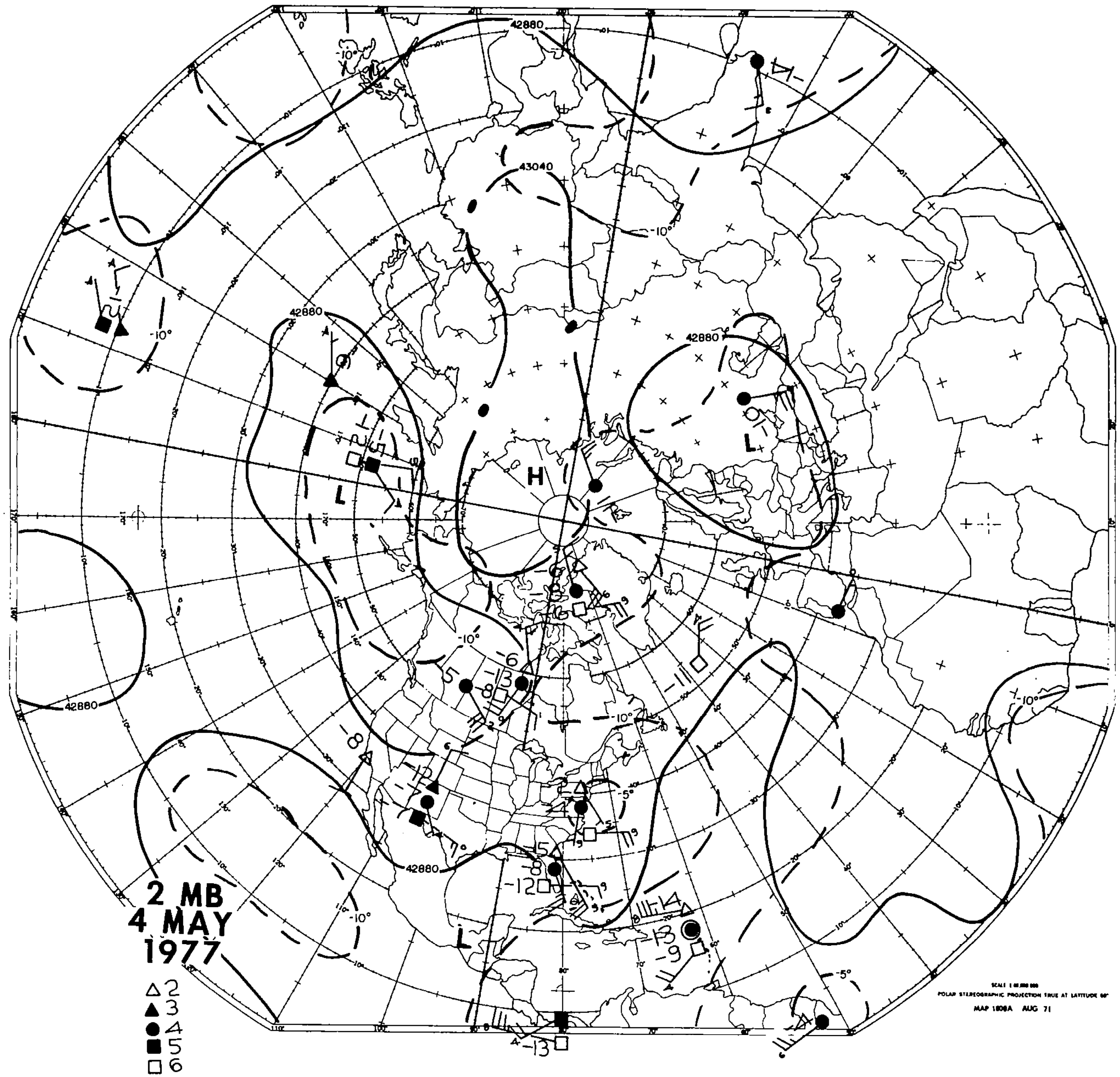

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1977
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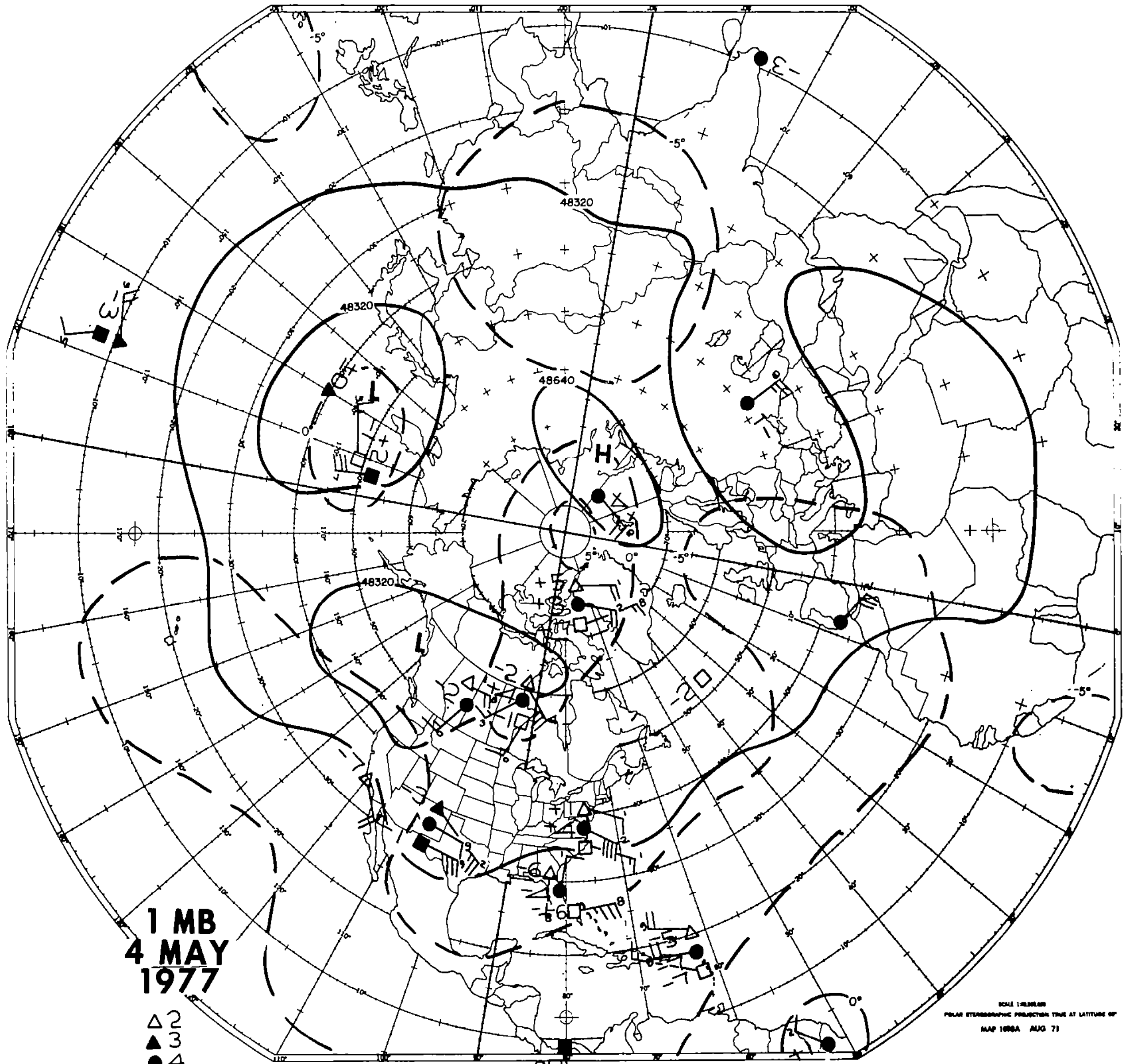
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1808A AUG 71



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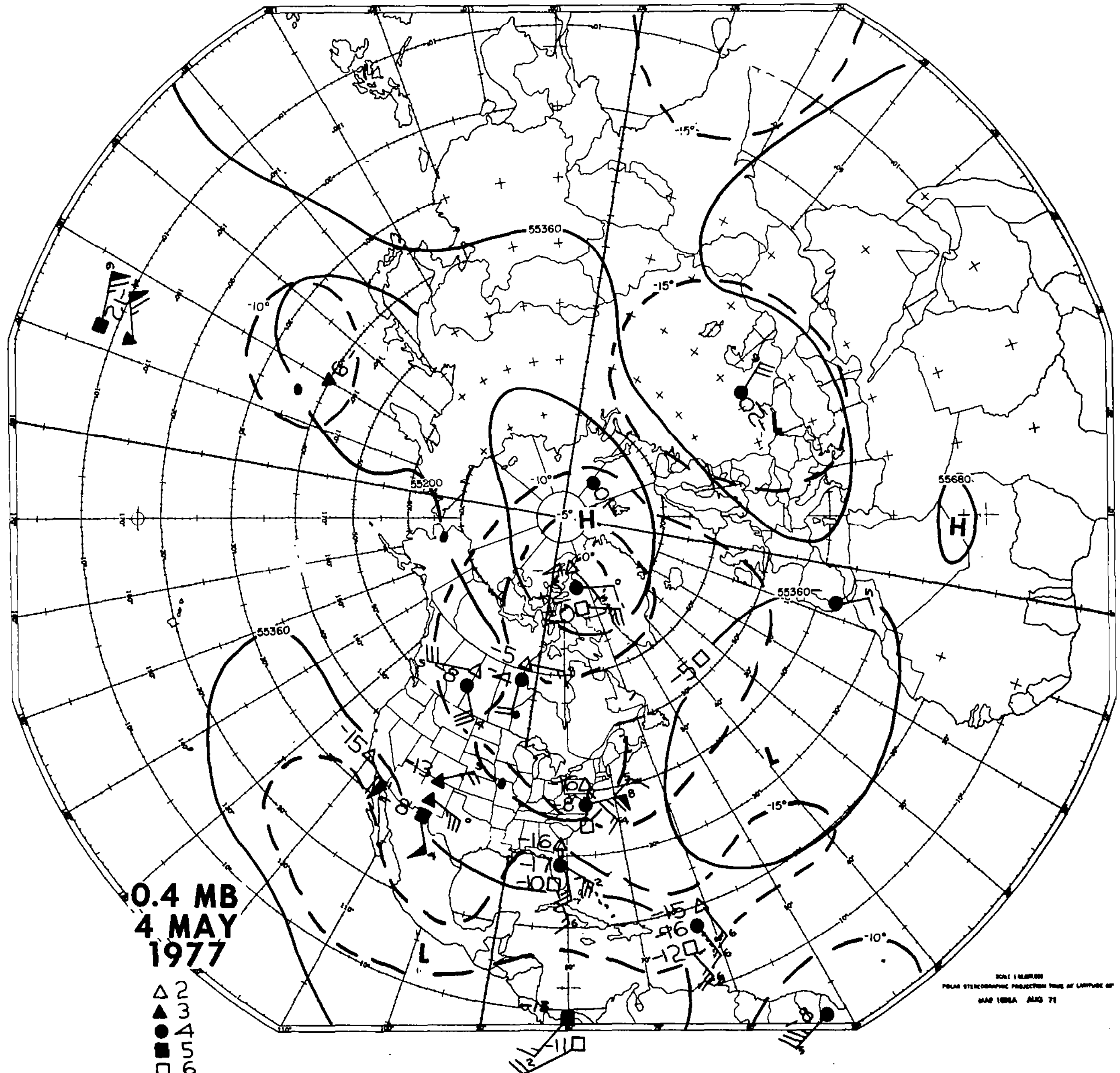
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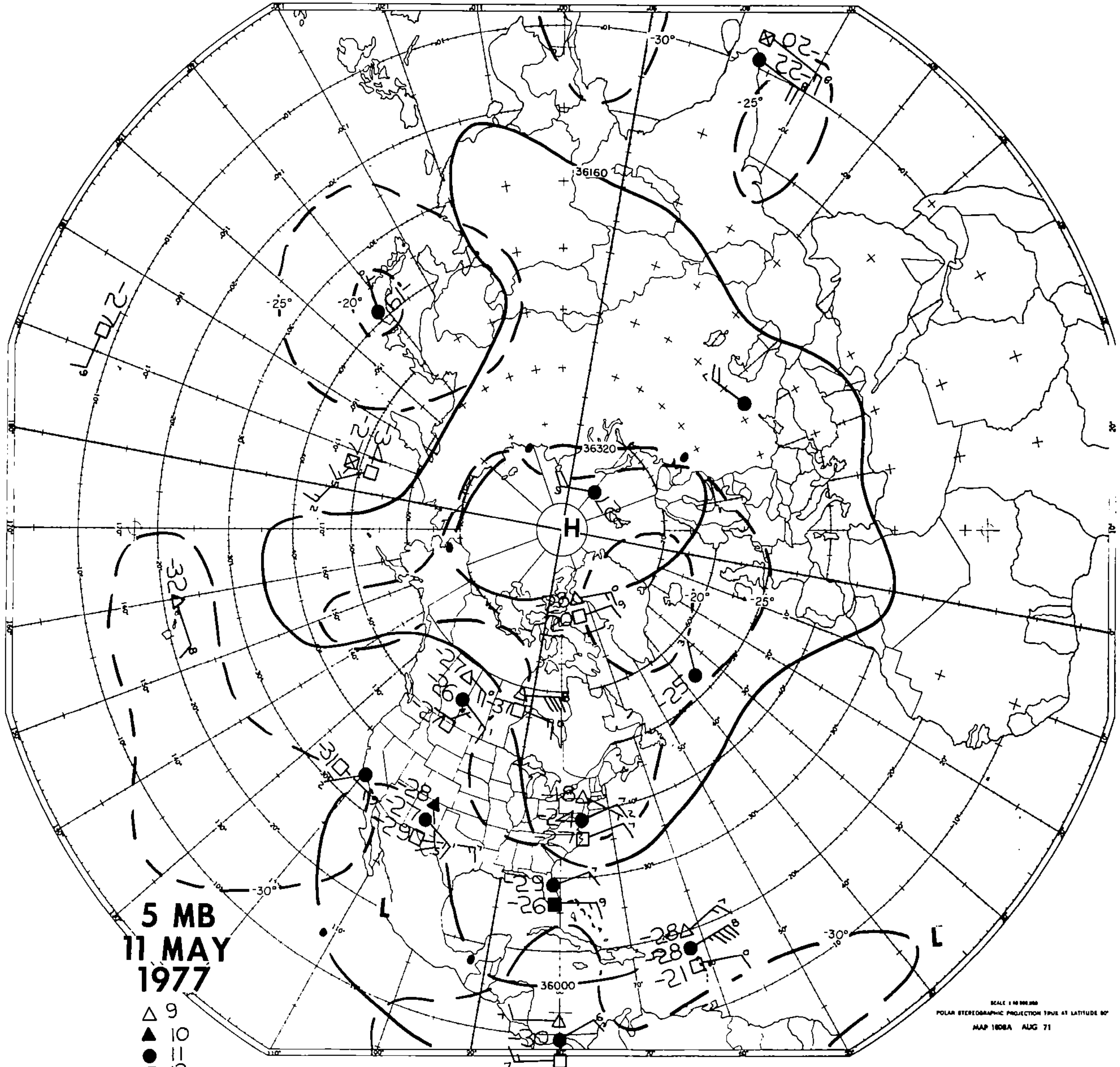
MAP 1098A AUG 71



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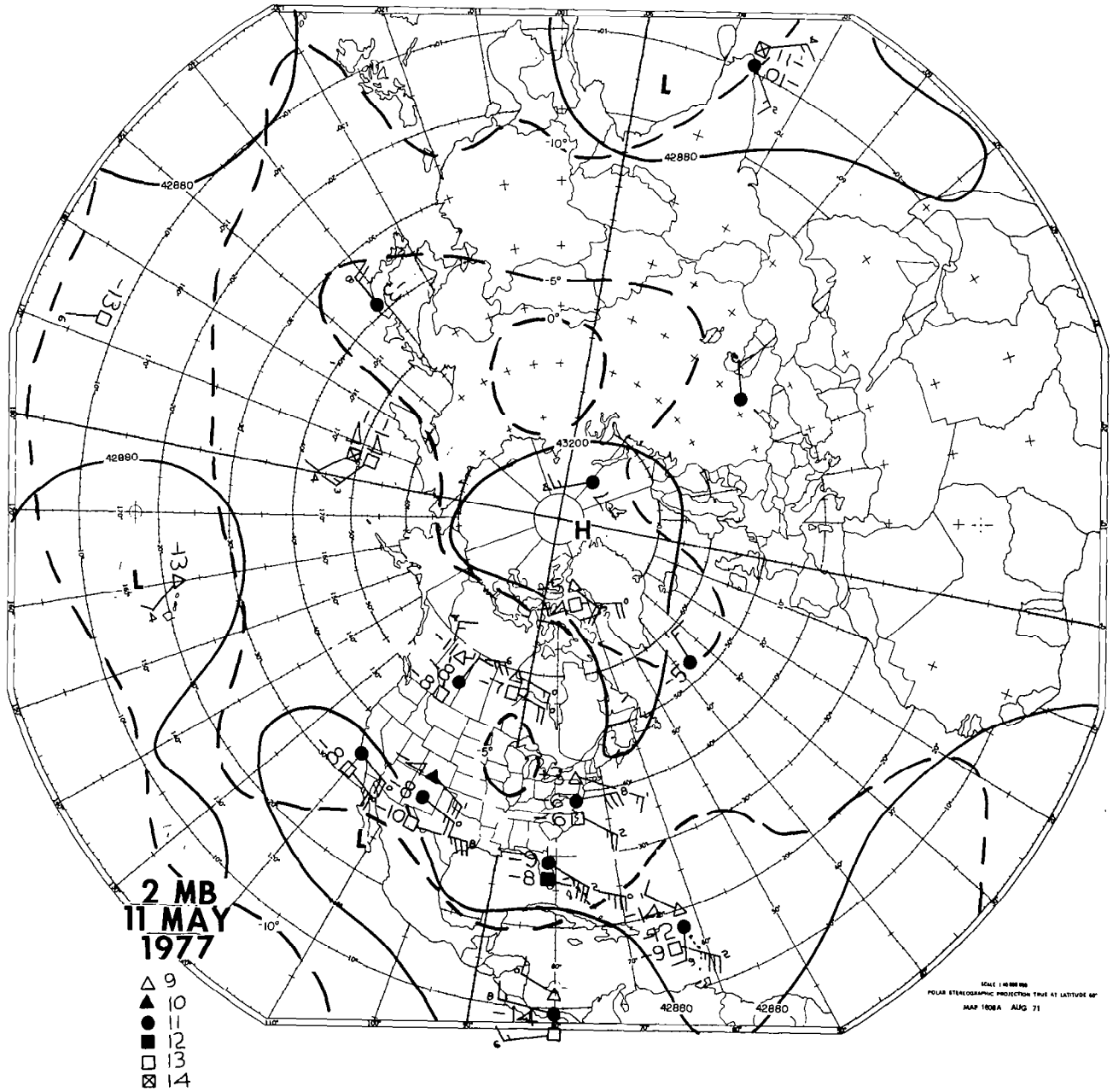
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11 MAY
1977
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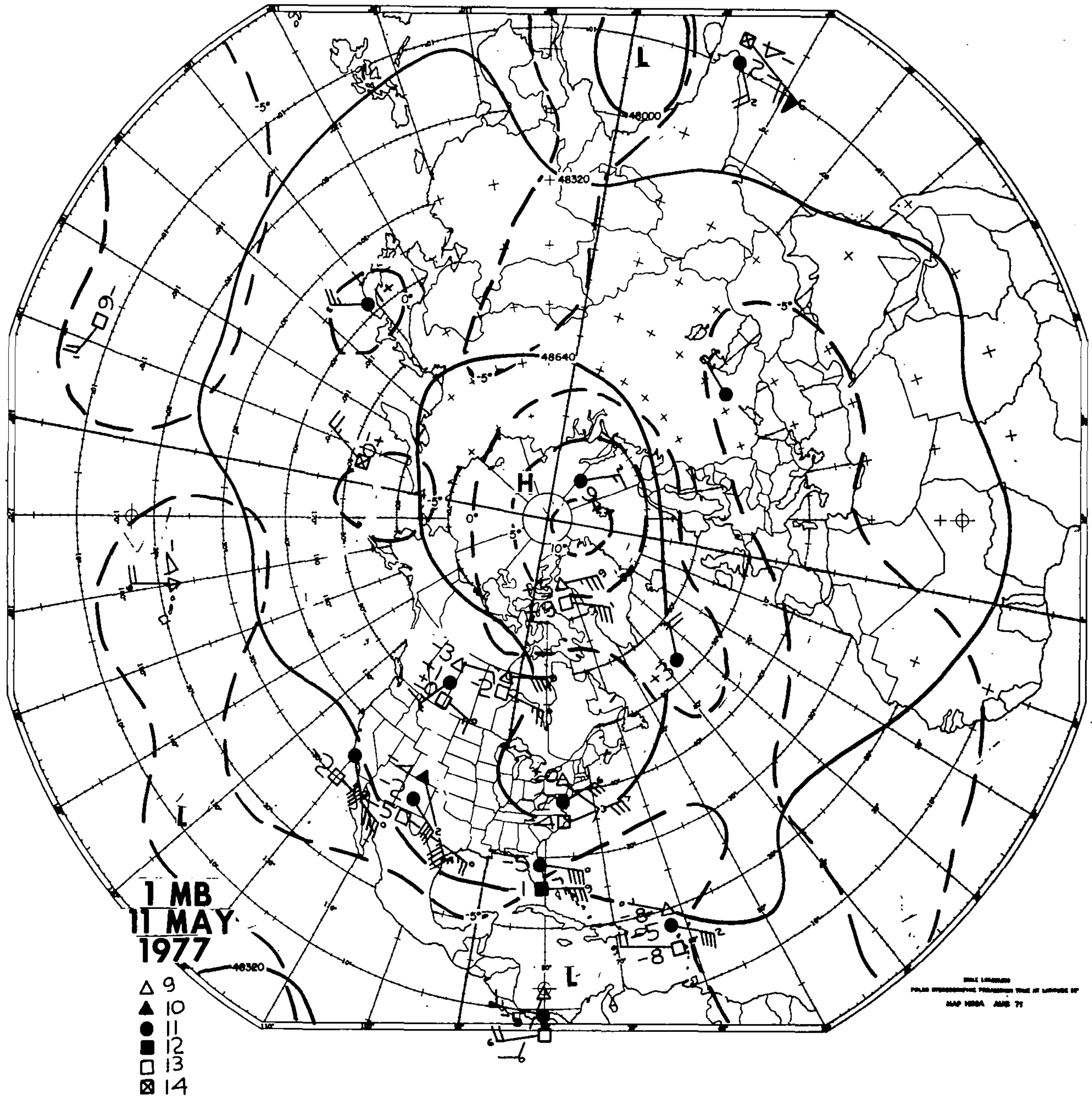
MAP 1808A AUG 71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L
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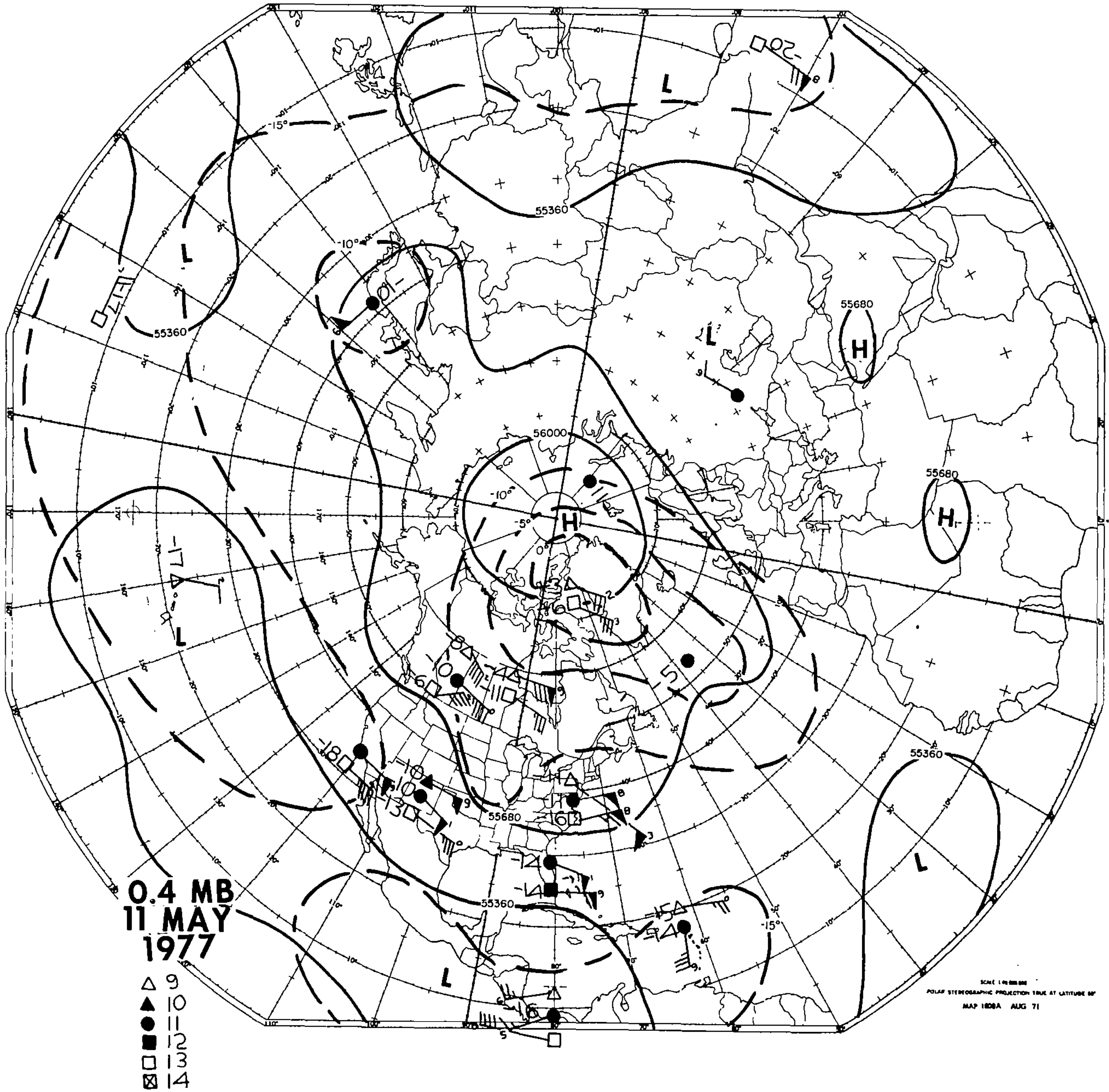
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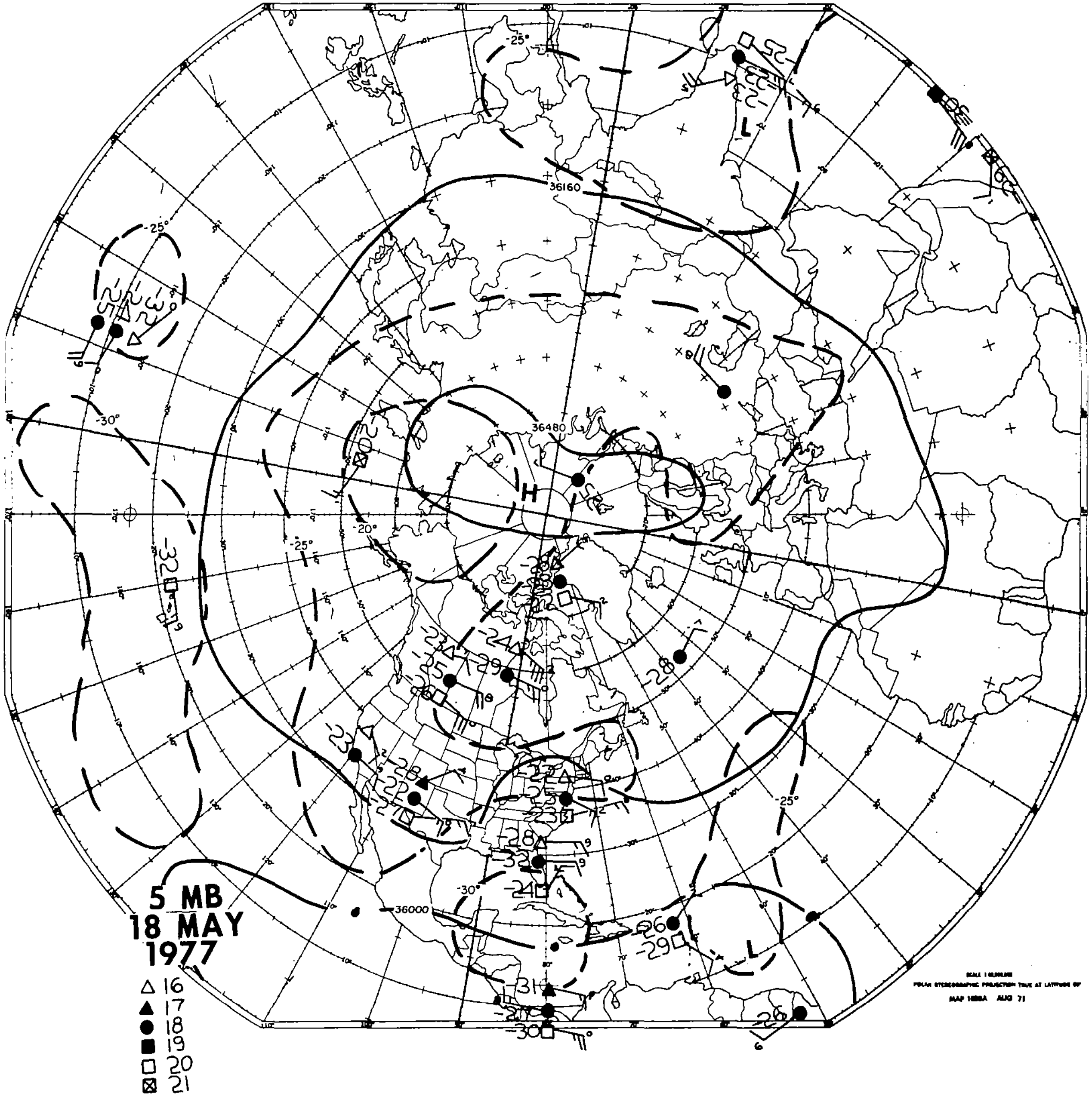
-10°
-15°
-5°
MAP 1808A AUG 71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1977
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▲ 17
● 18
■ 19
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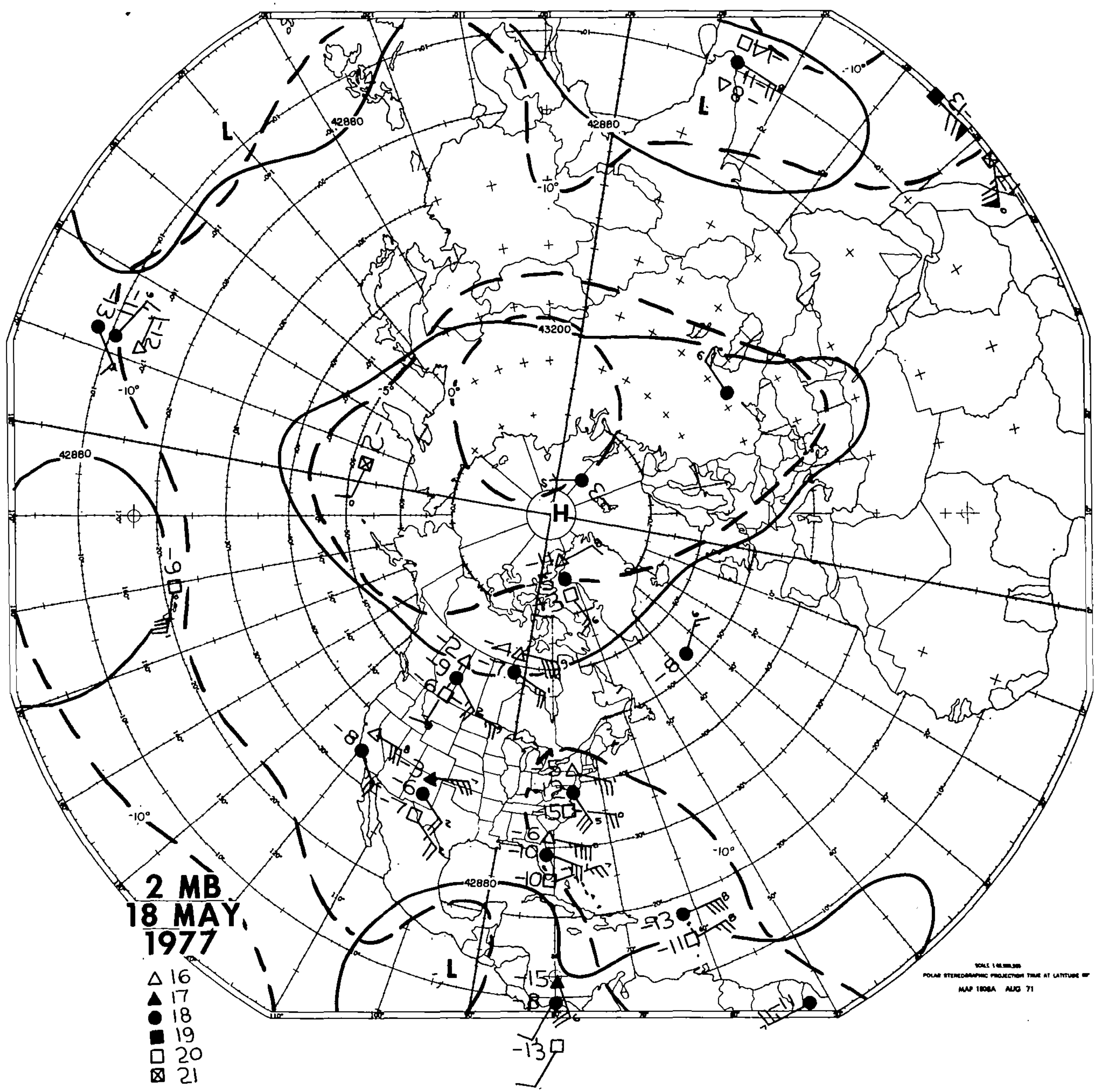
-30°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▲ 17
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■ 19
□ 20
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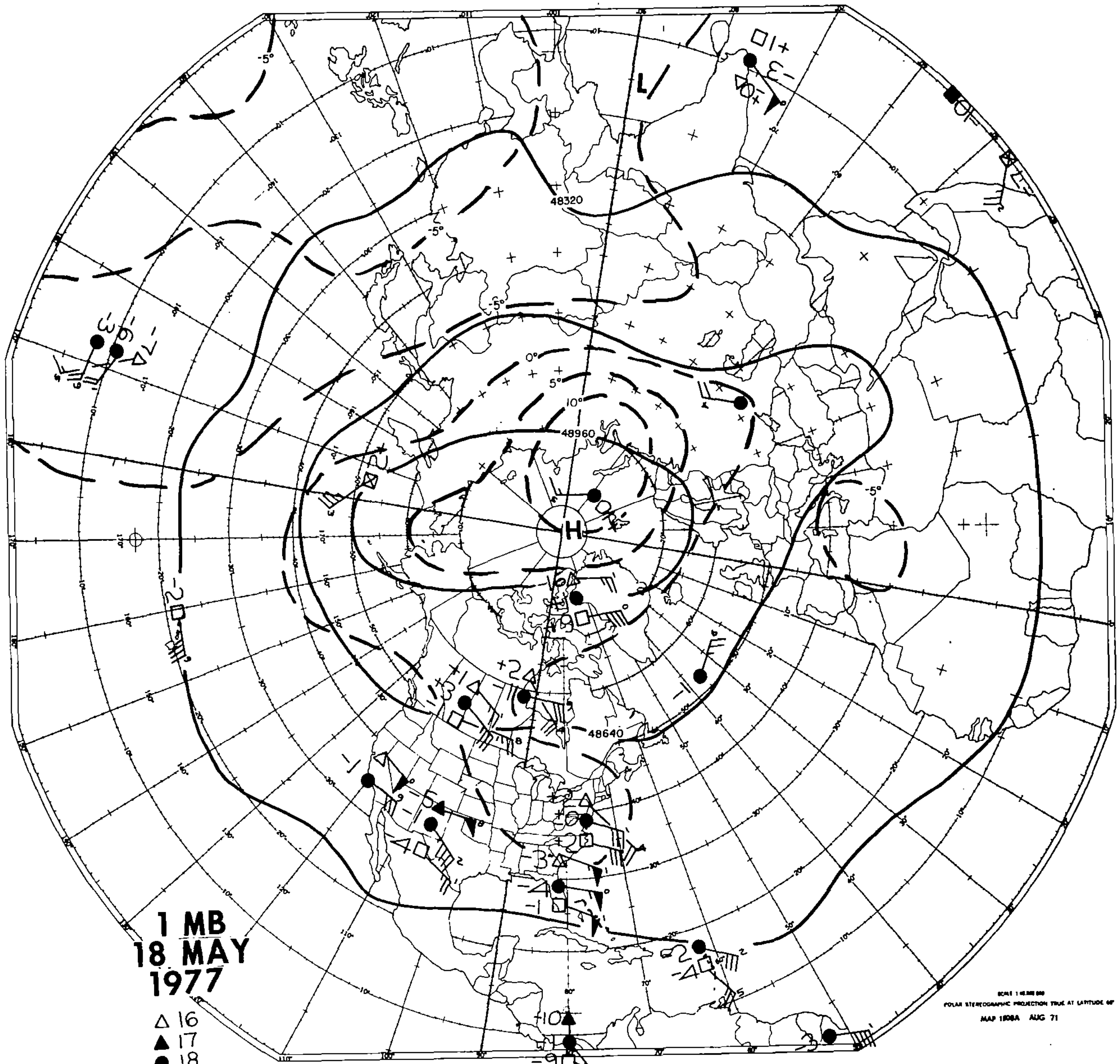
MAP 1808A AUG 71
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°



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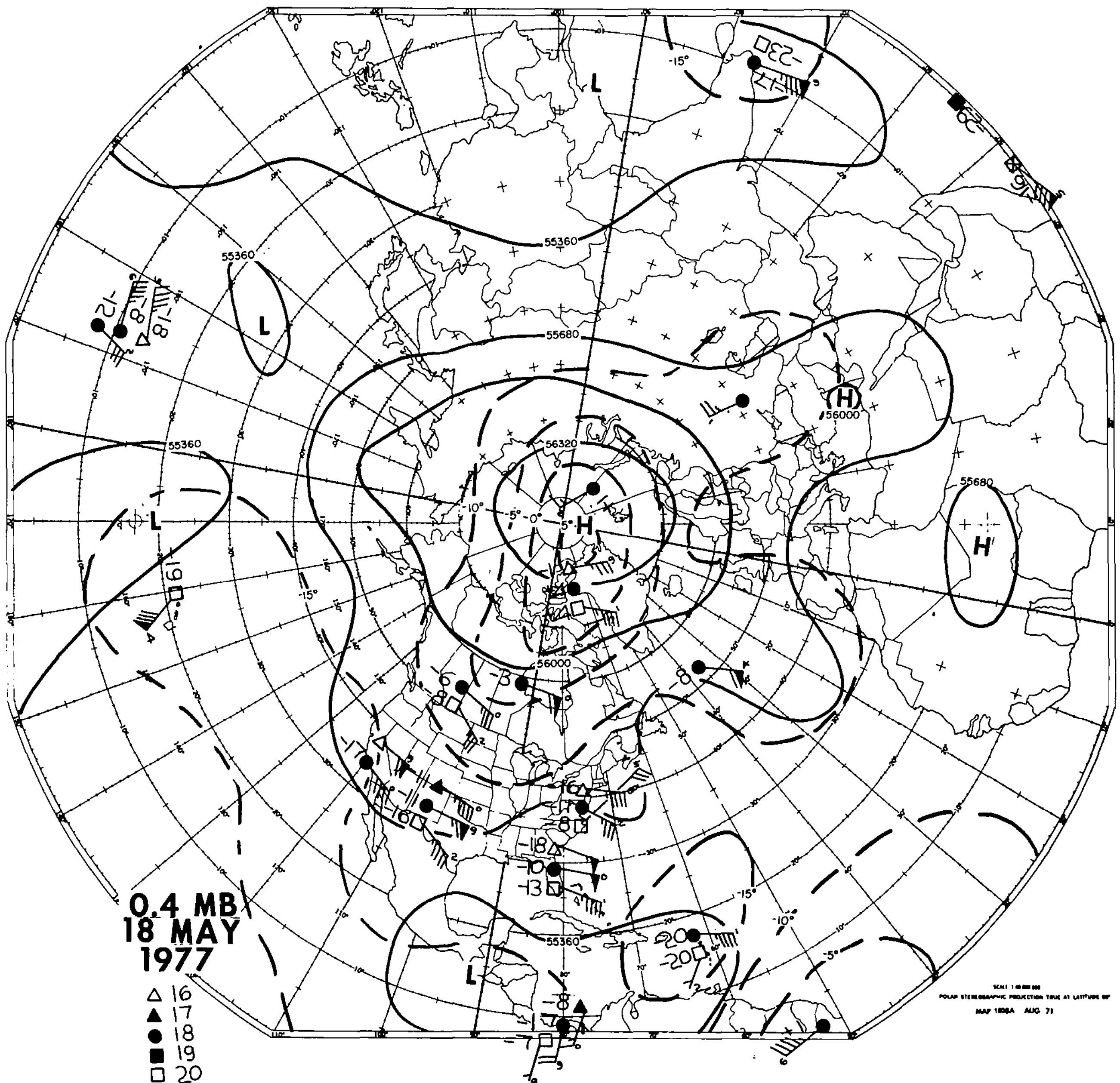
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1977
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■ 19
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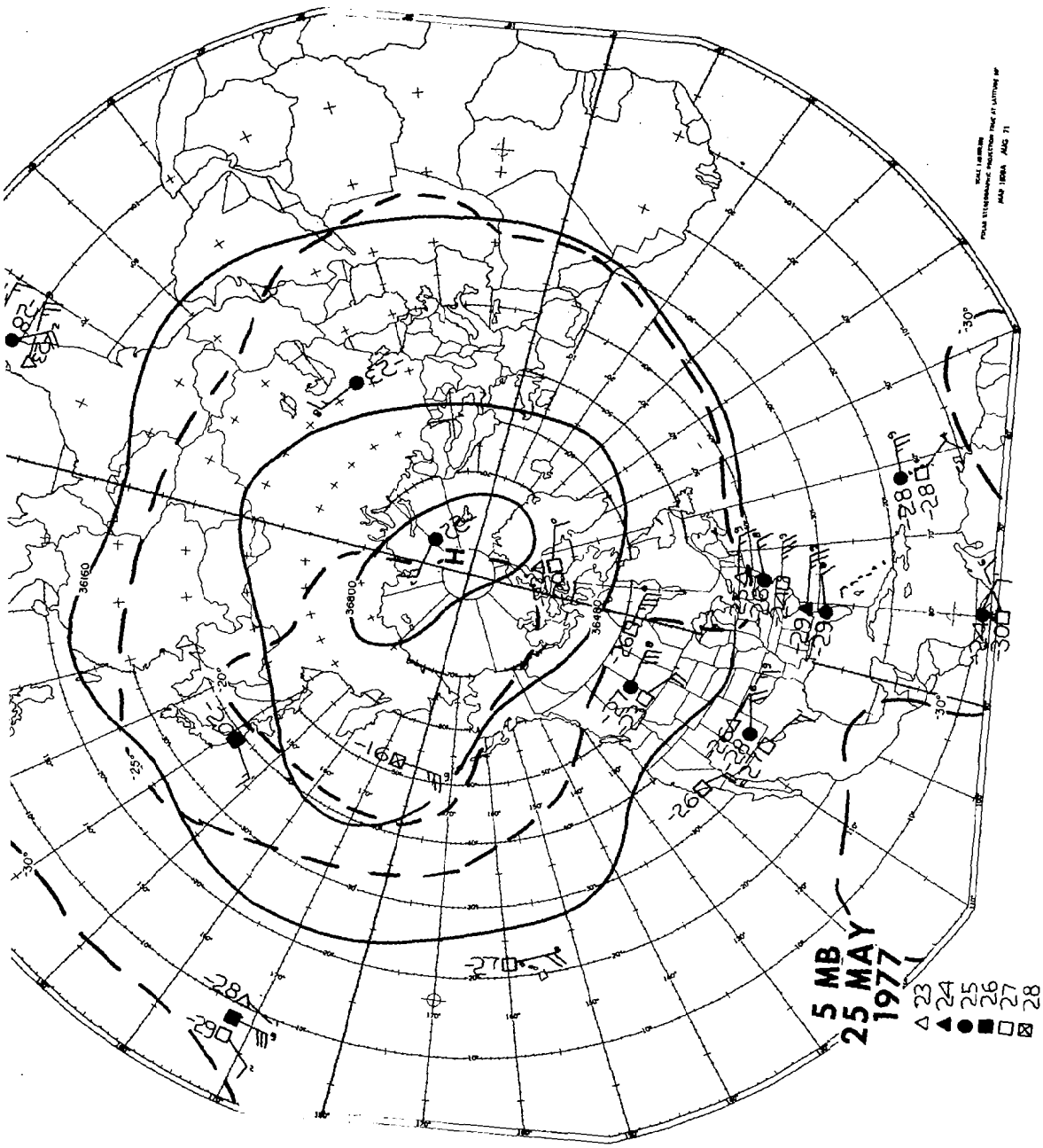
MAP 1808A AUG 71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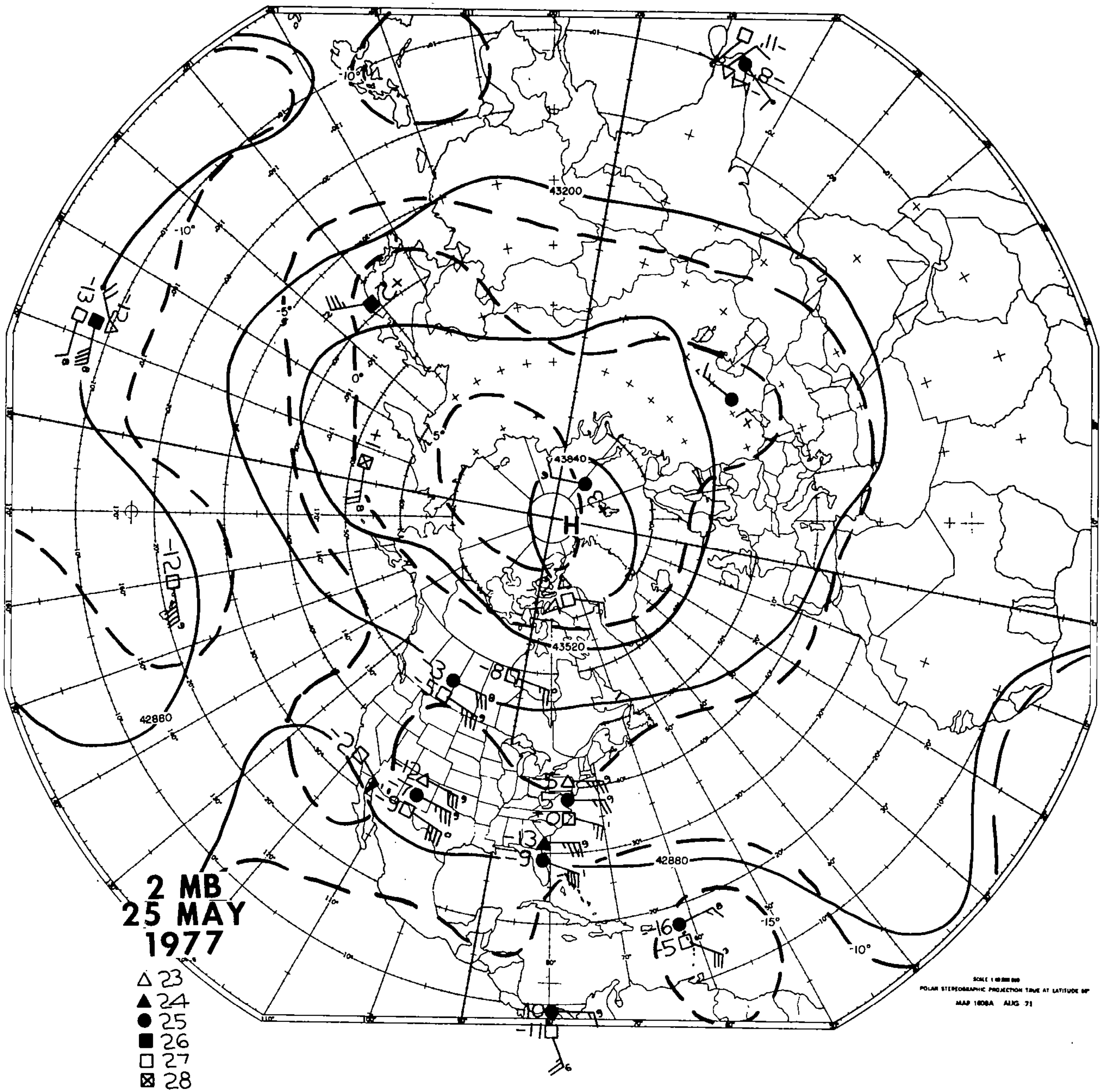
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25 MAY
1977
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▲ 24
● 25
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⊠ 28
43200
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43520
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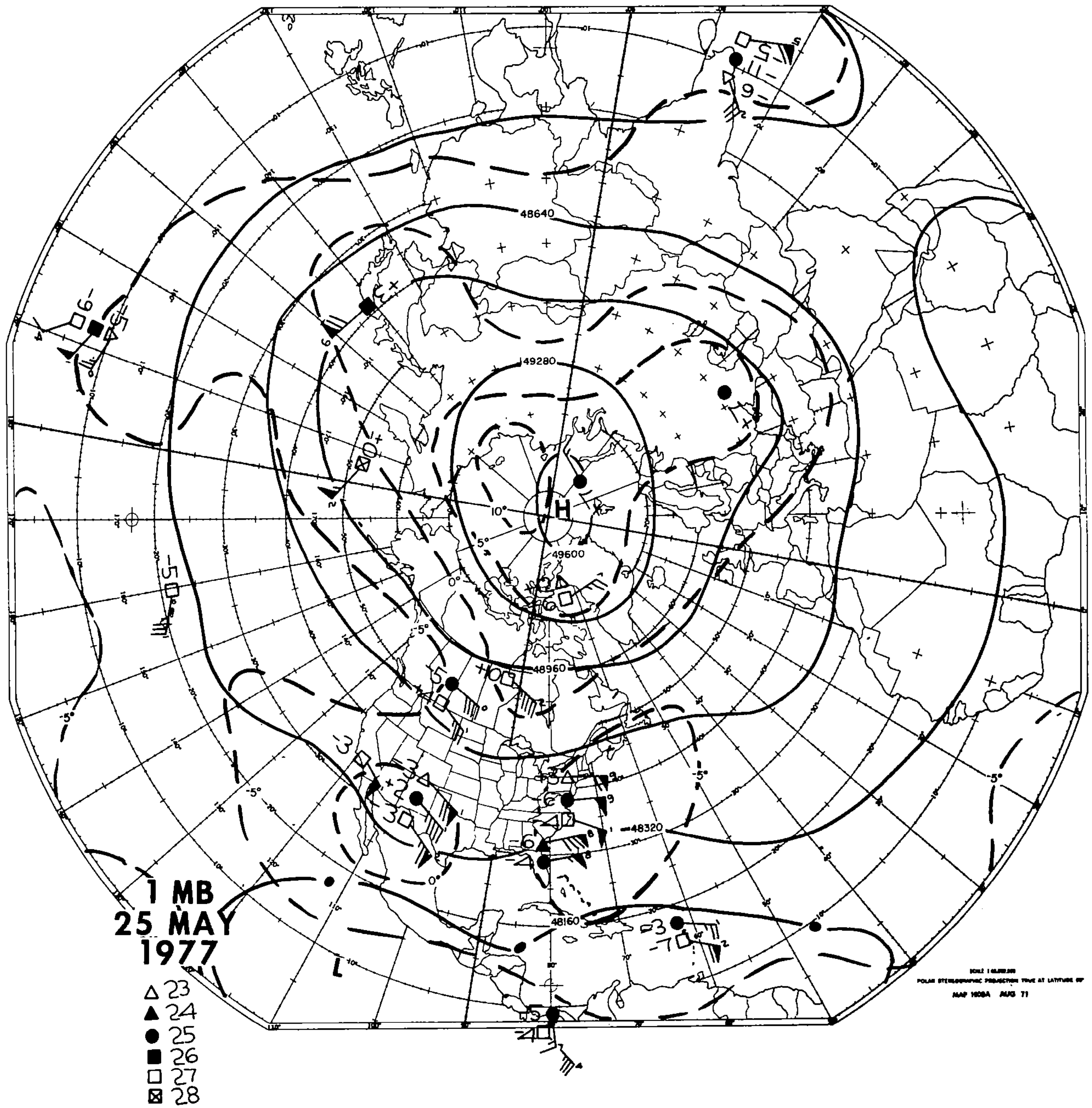
POLAR STEREOGRAPHIC PROJECTION TRUE AT LATITUDE 60°
MAP 1608A AUG 71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1977
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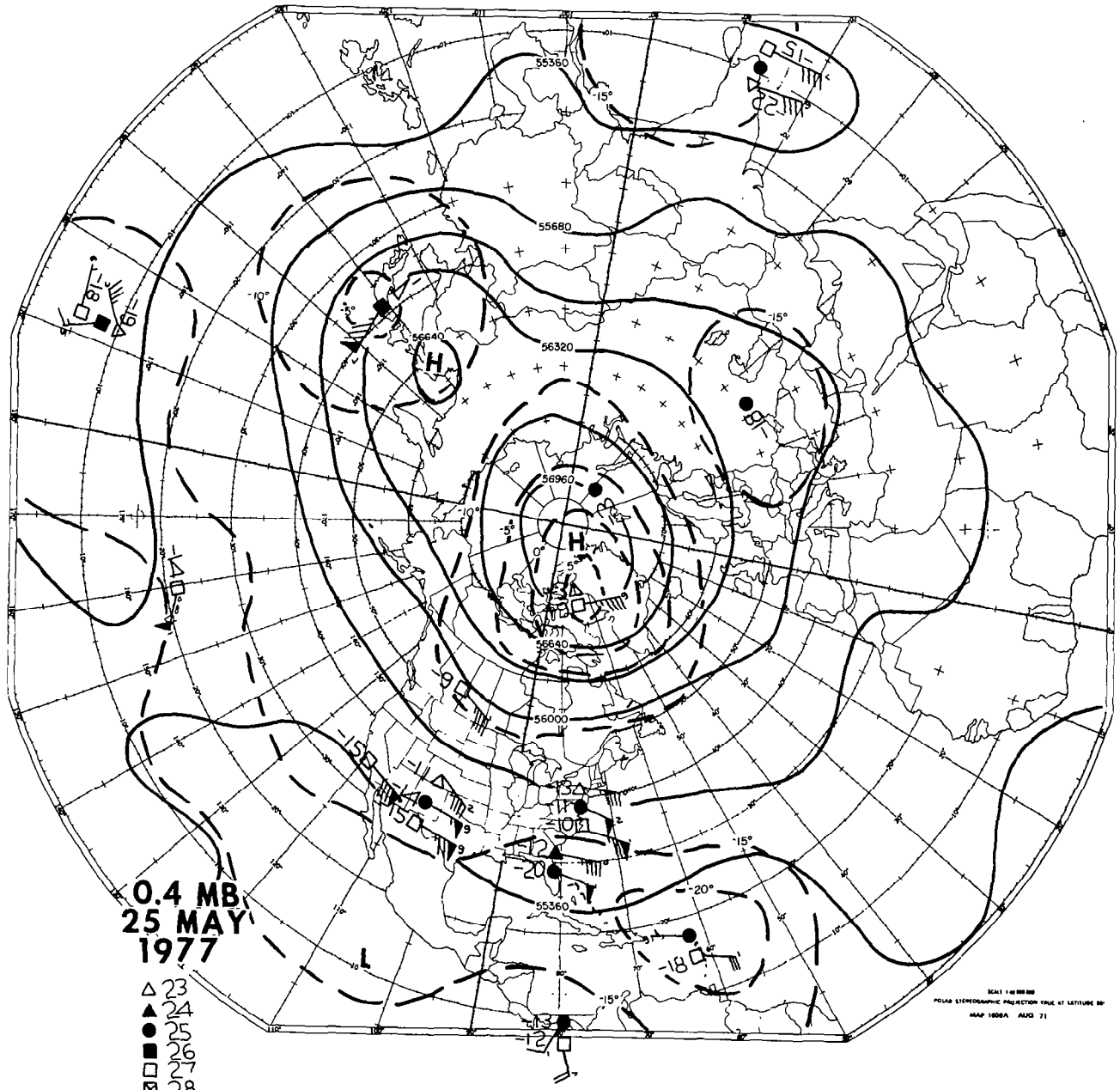
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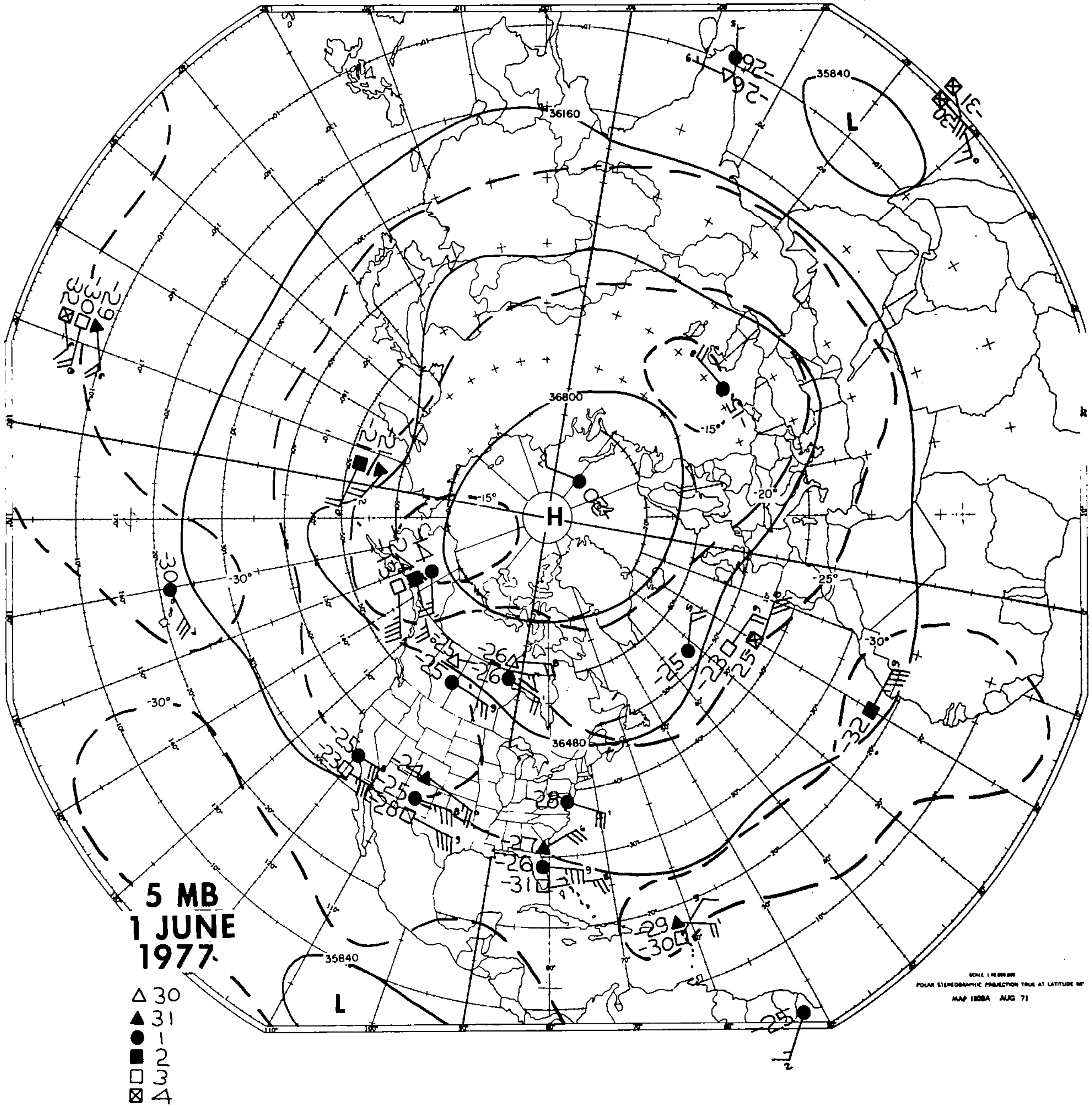
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⊠ 4
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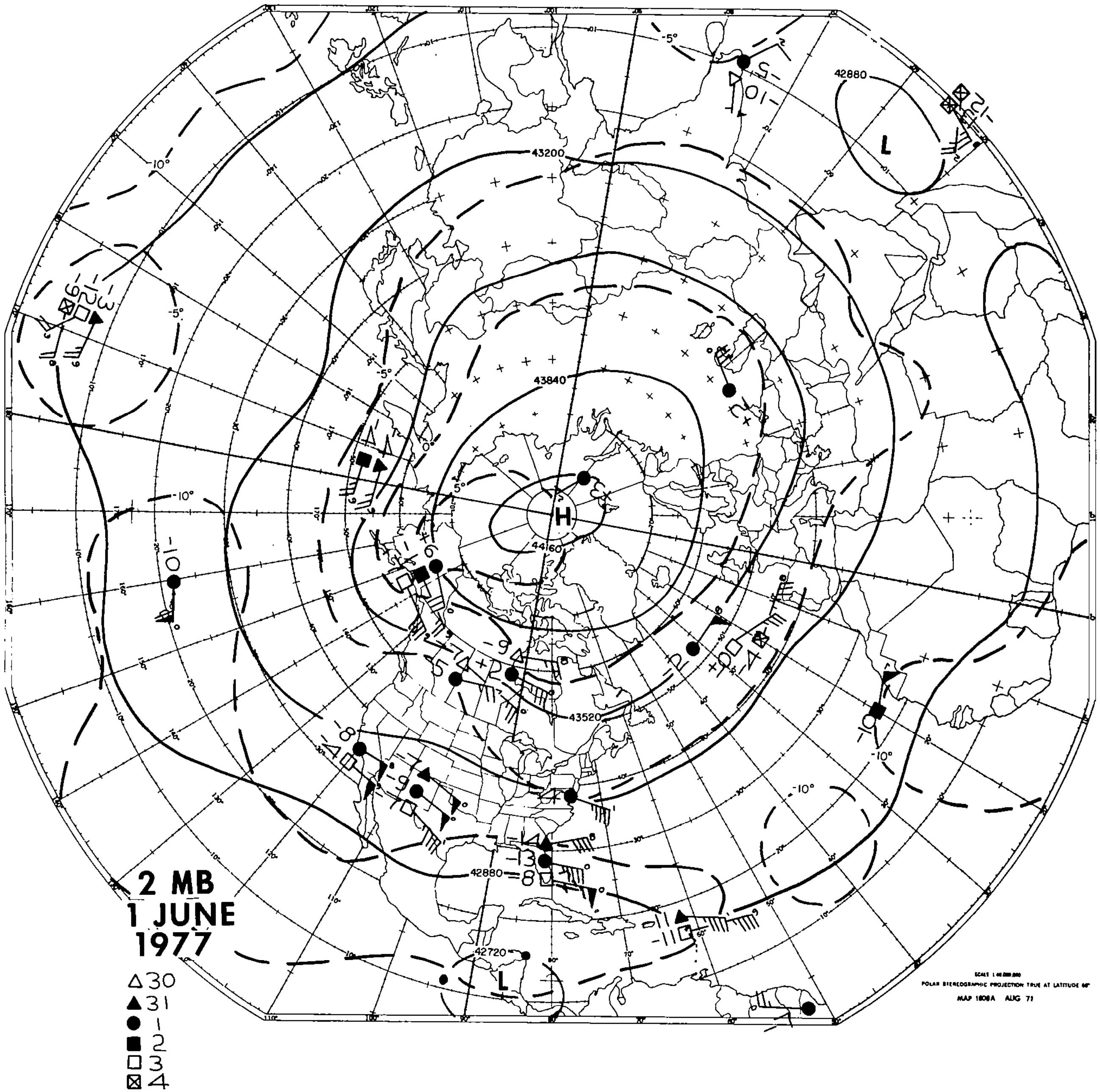
MAP 1808A AUG 71



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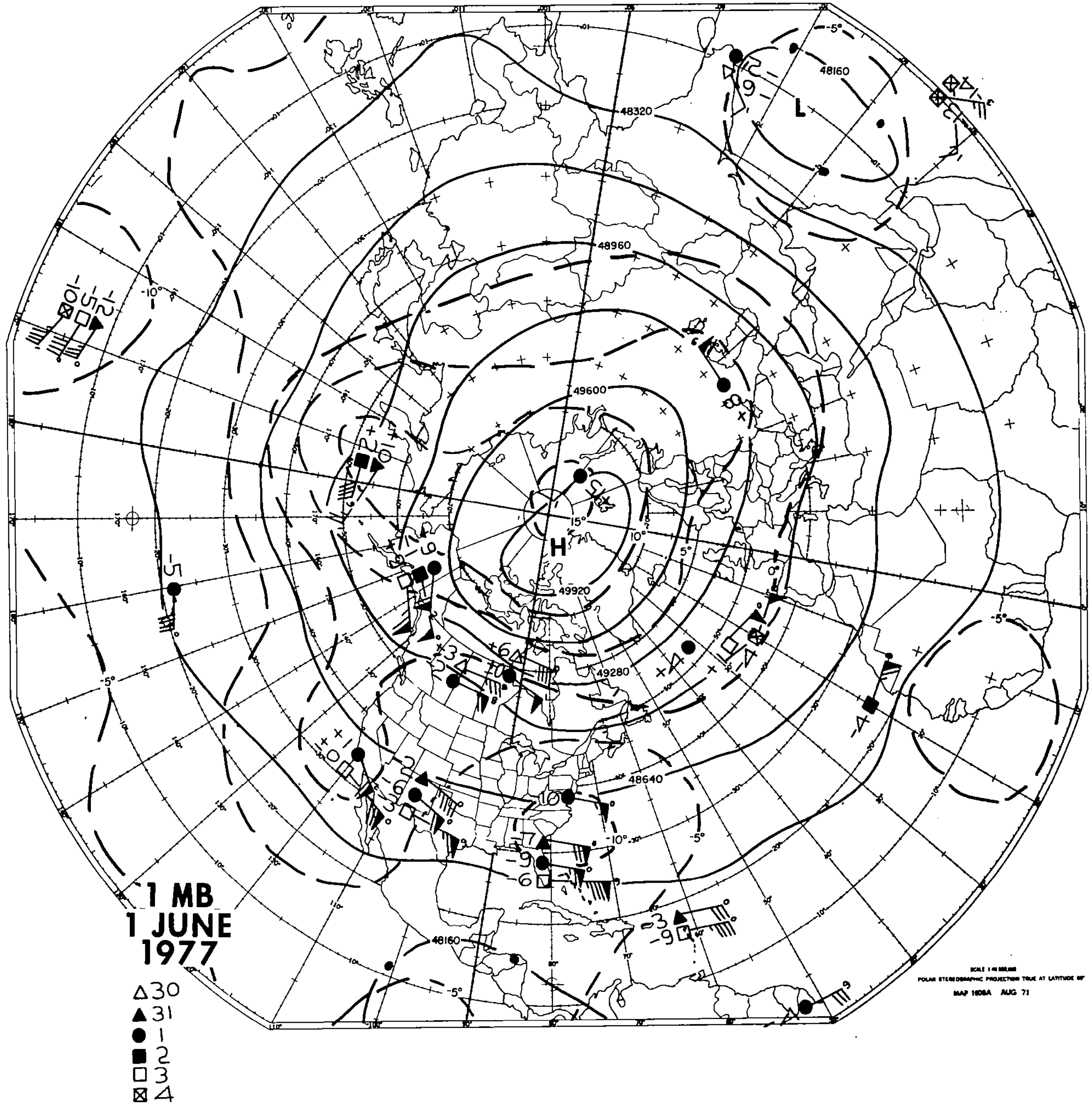

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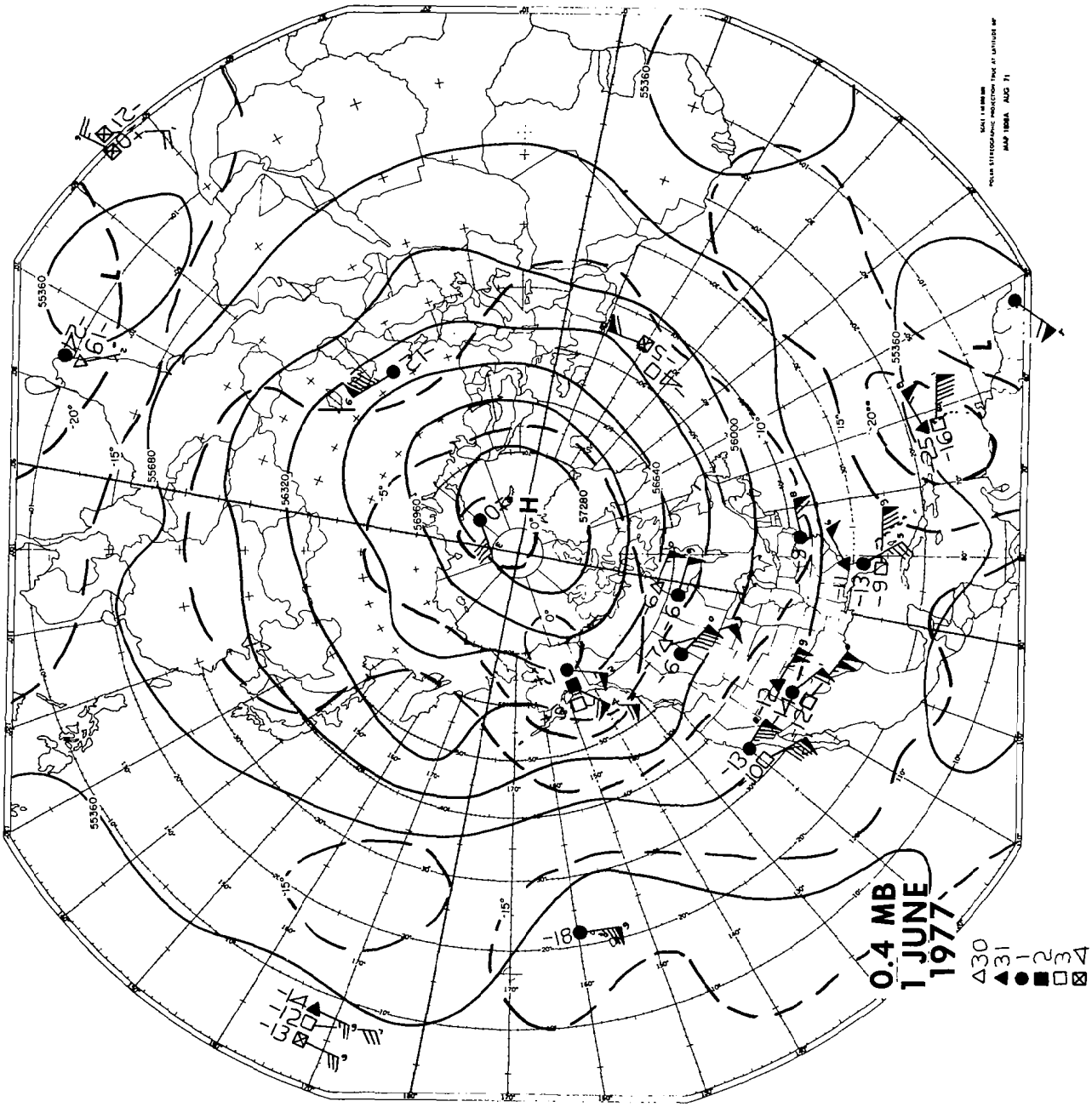
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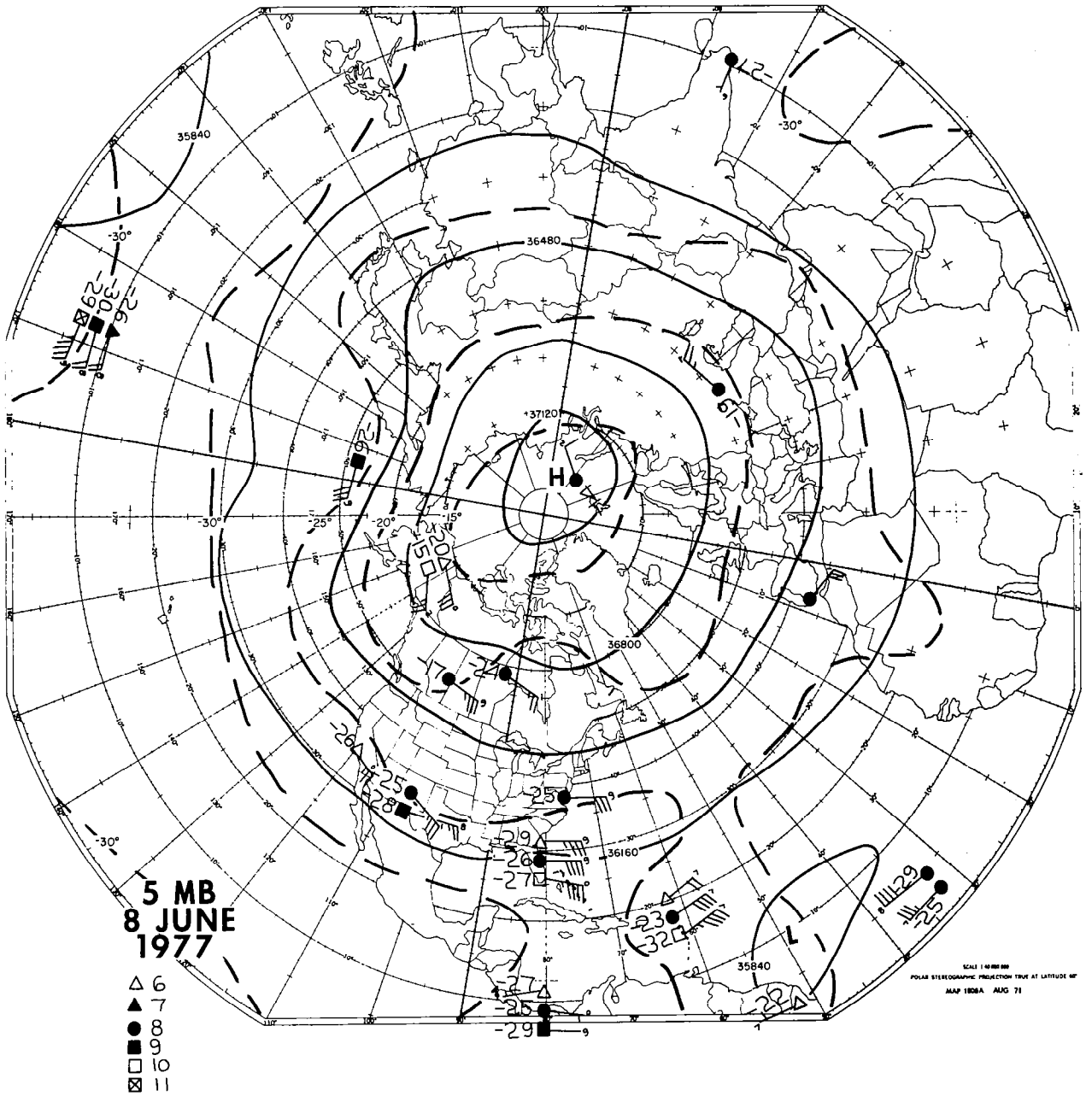
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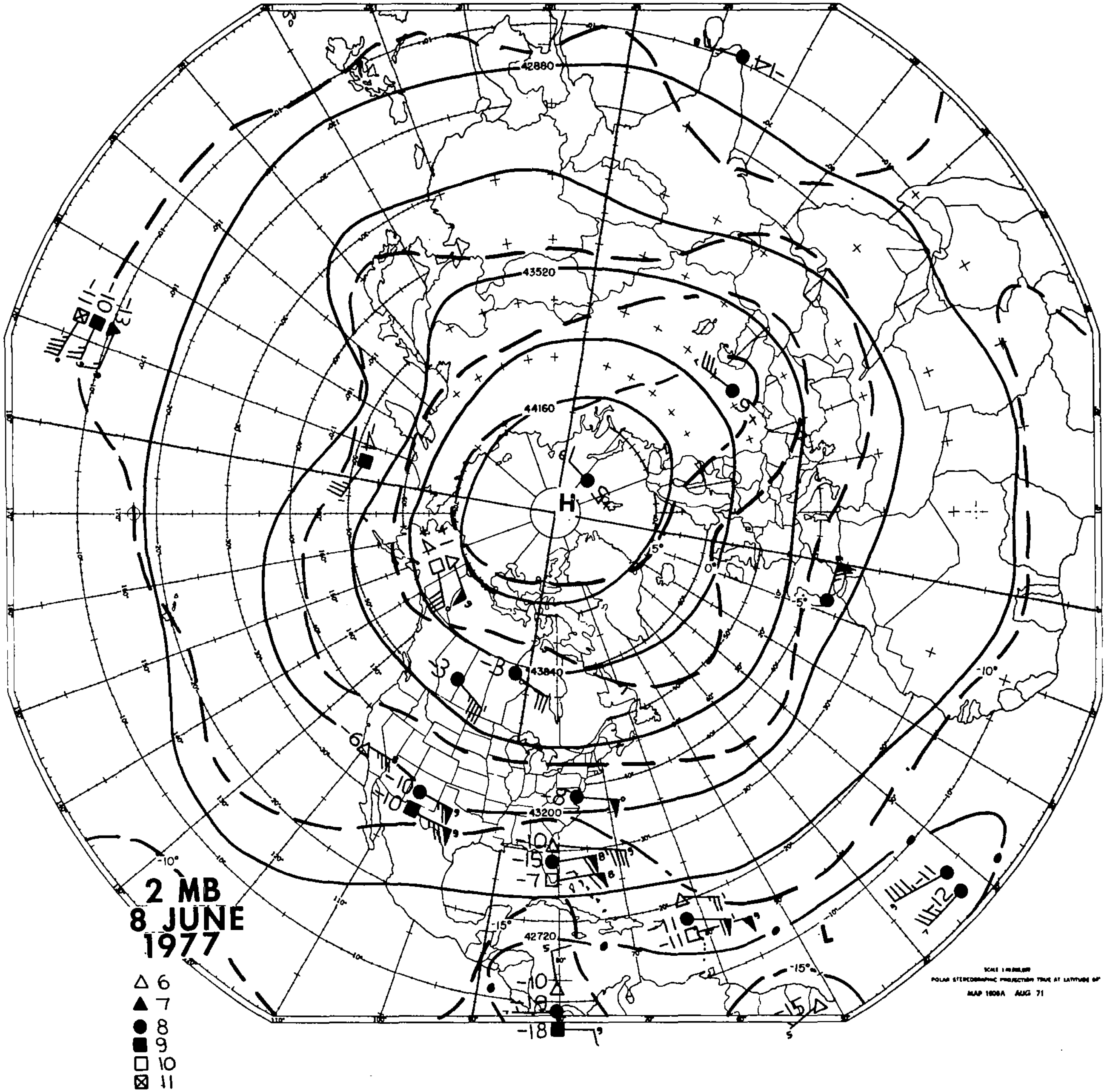
MAP 1808A AUG 71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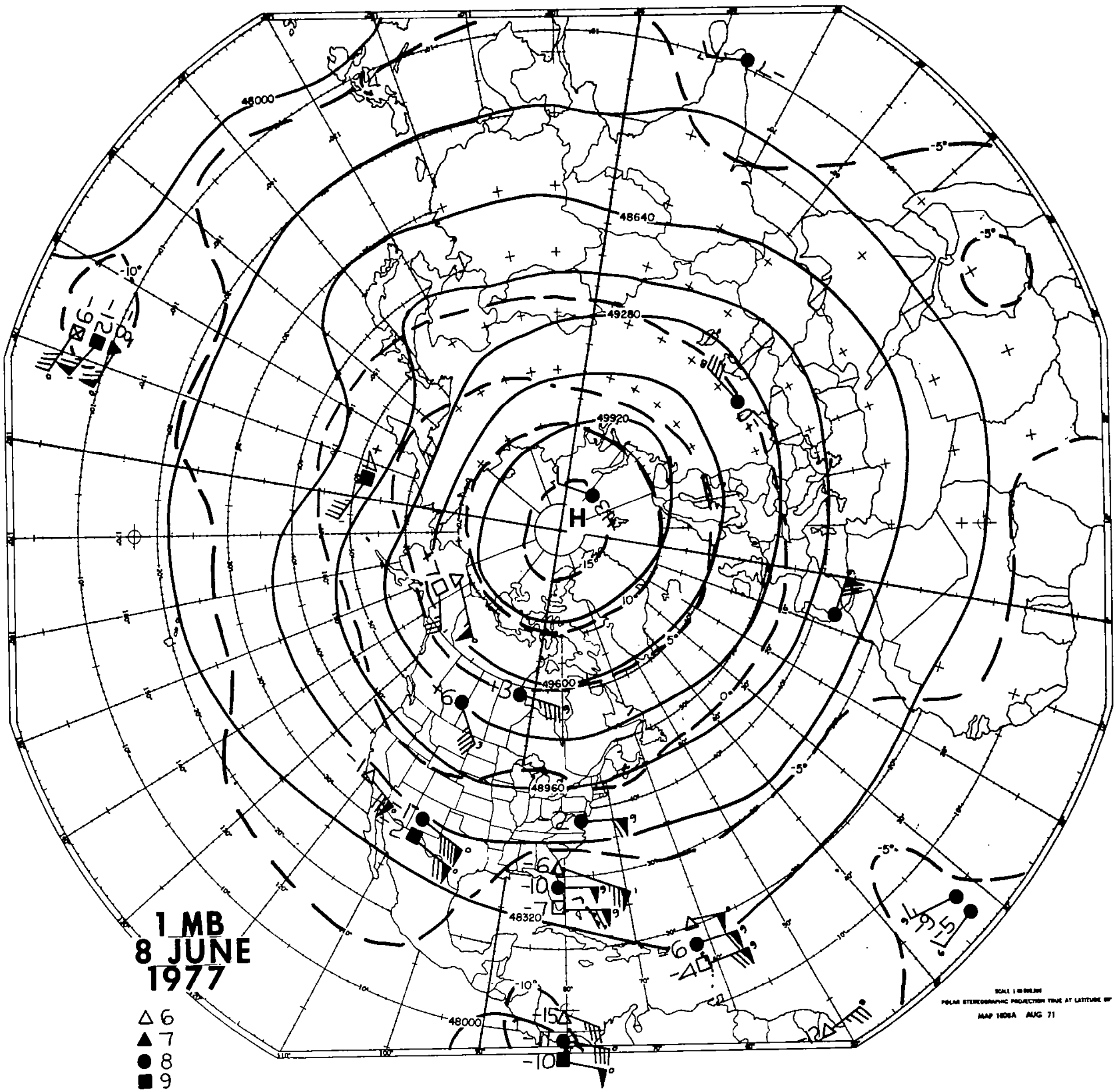
MAP 1606A AUG 71



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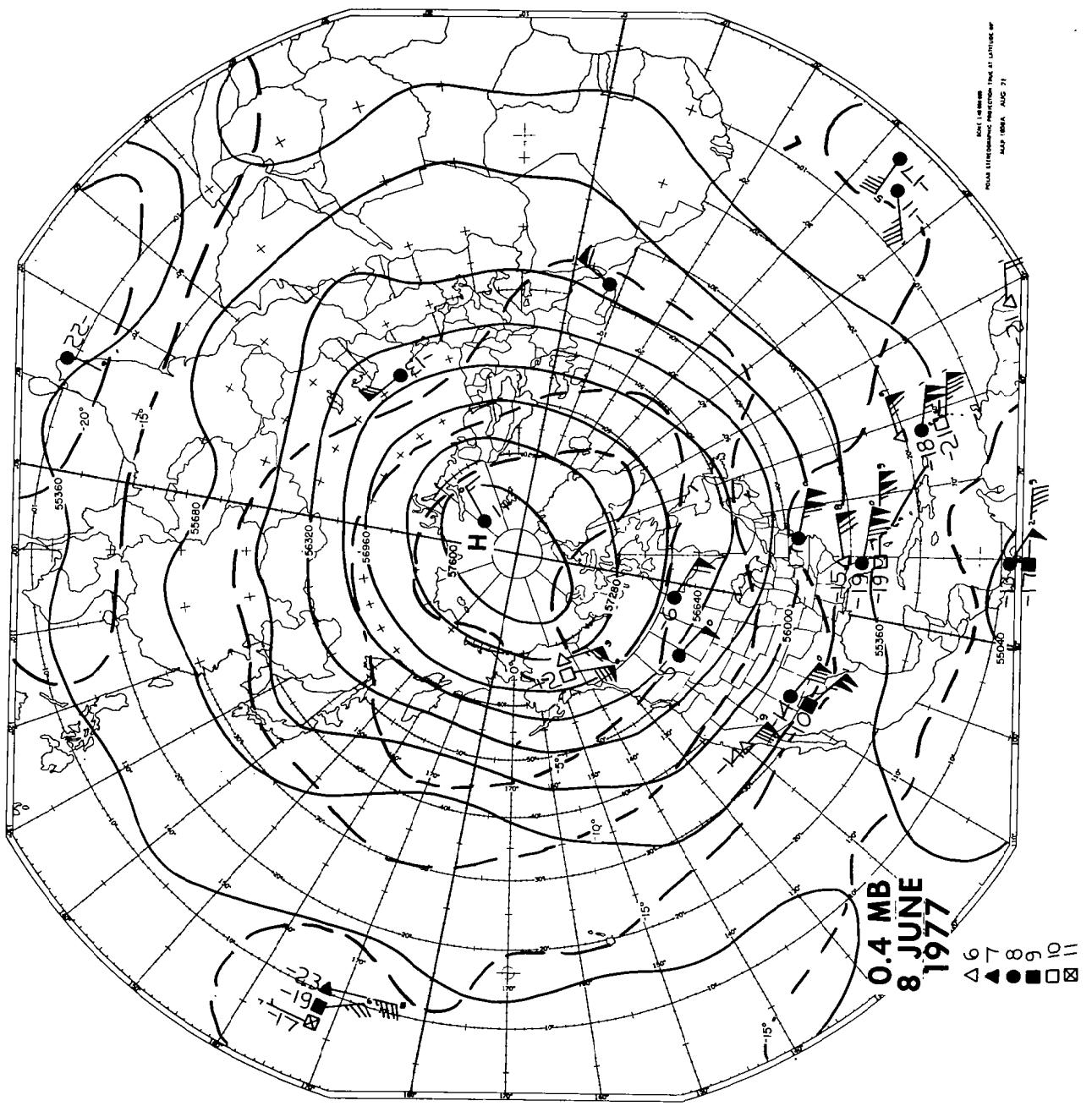
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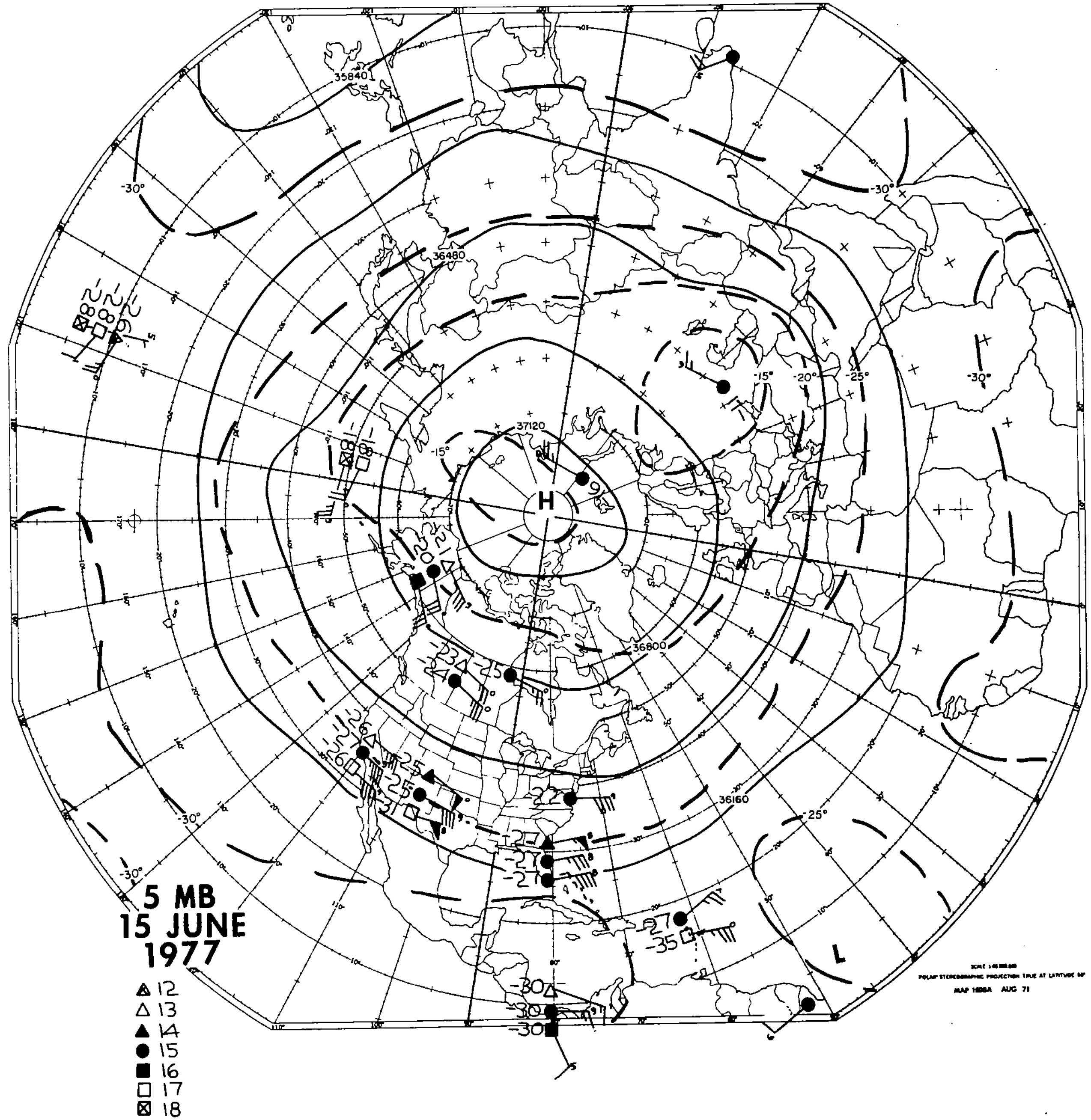
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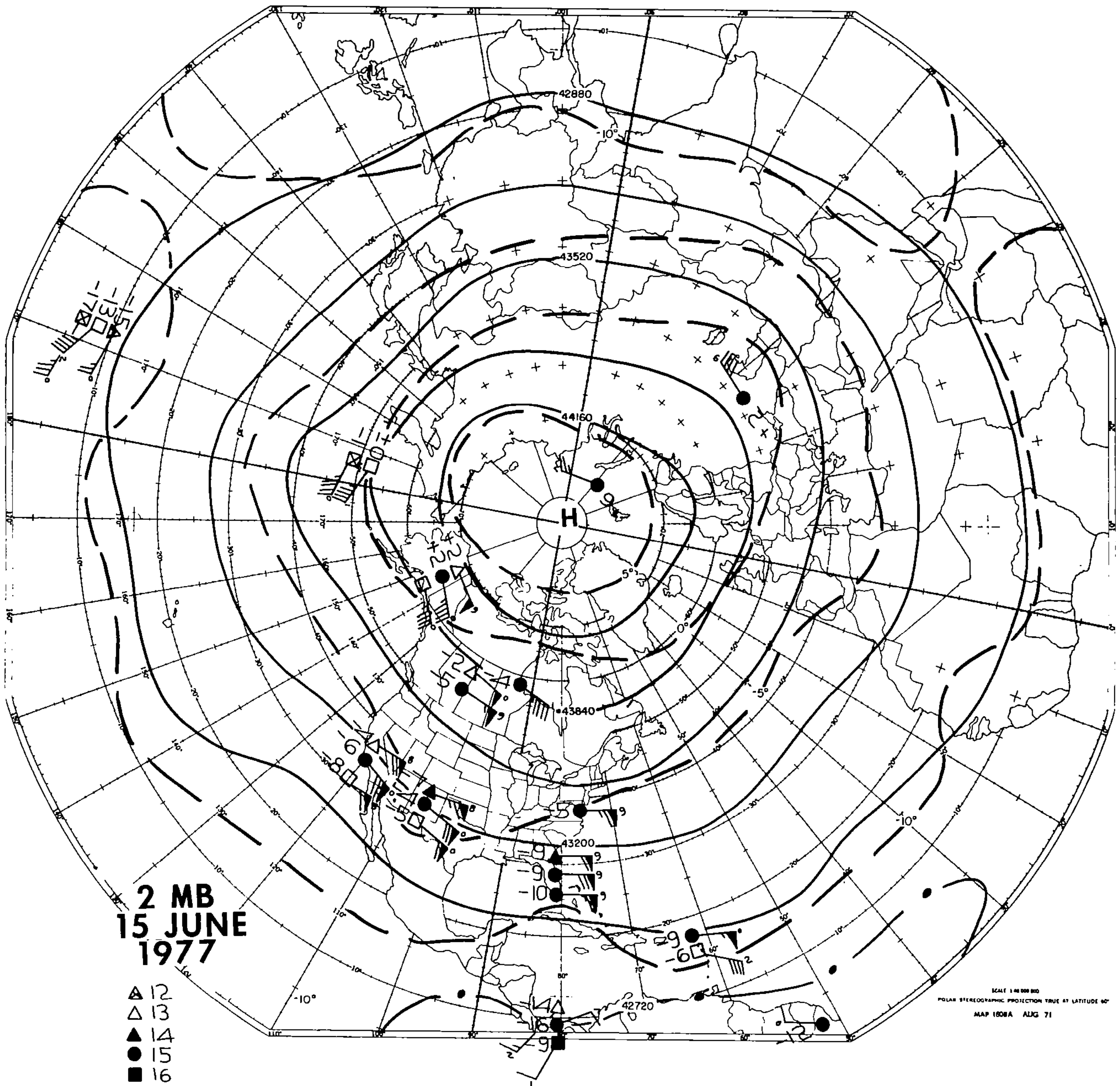
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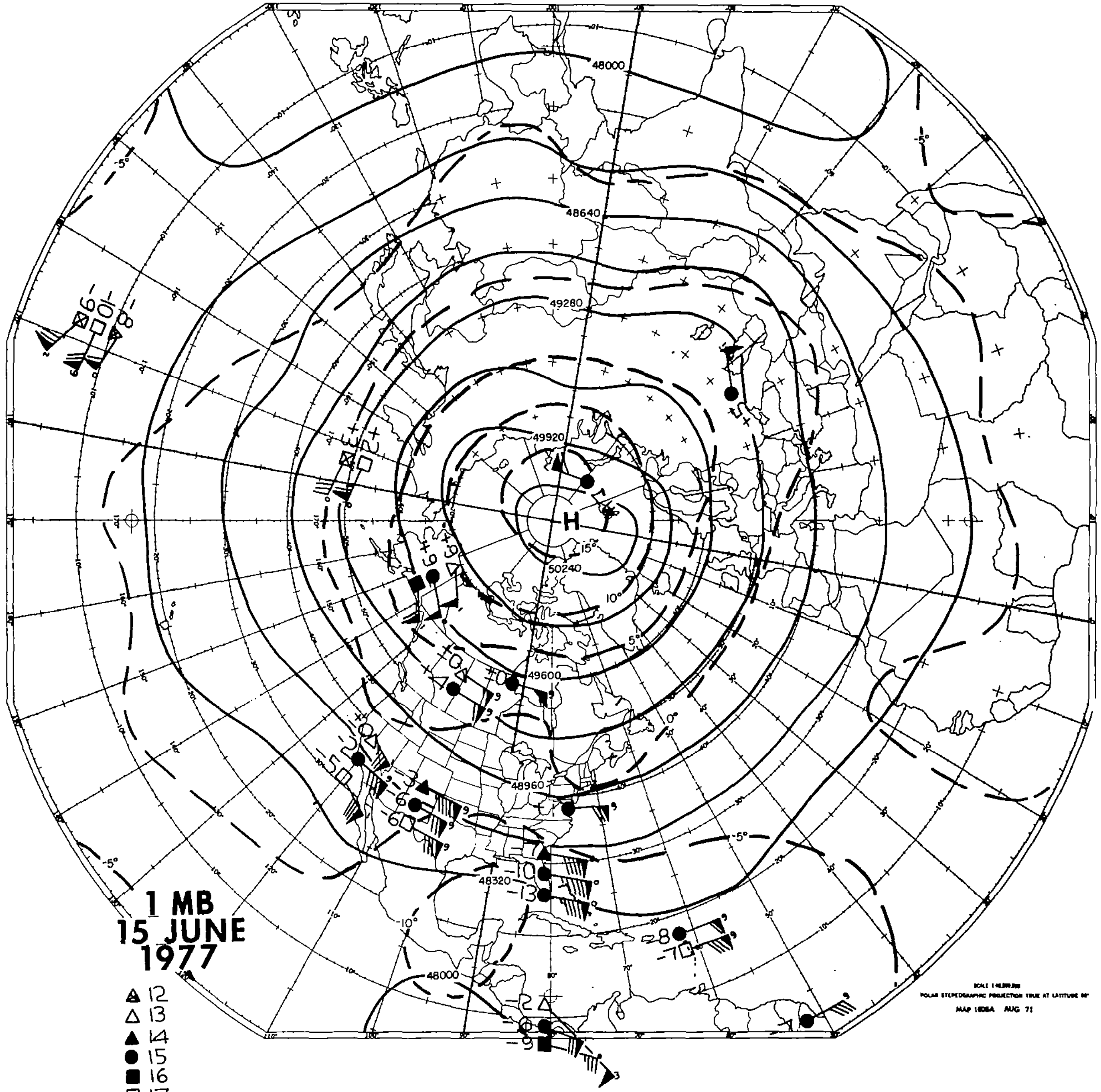

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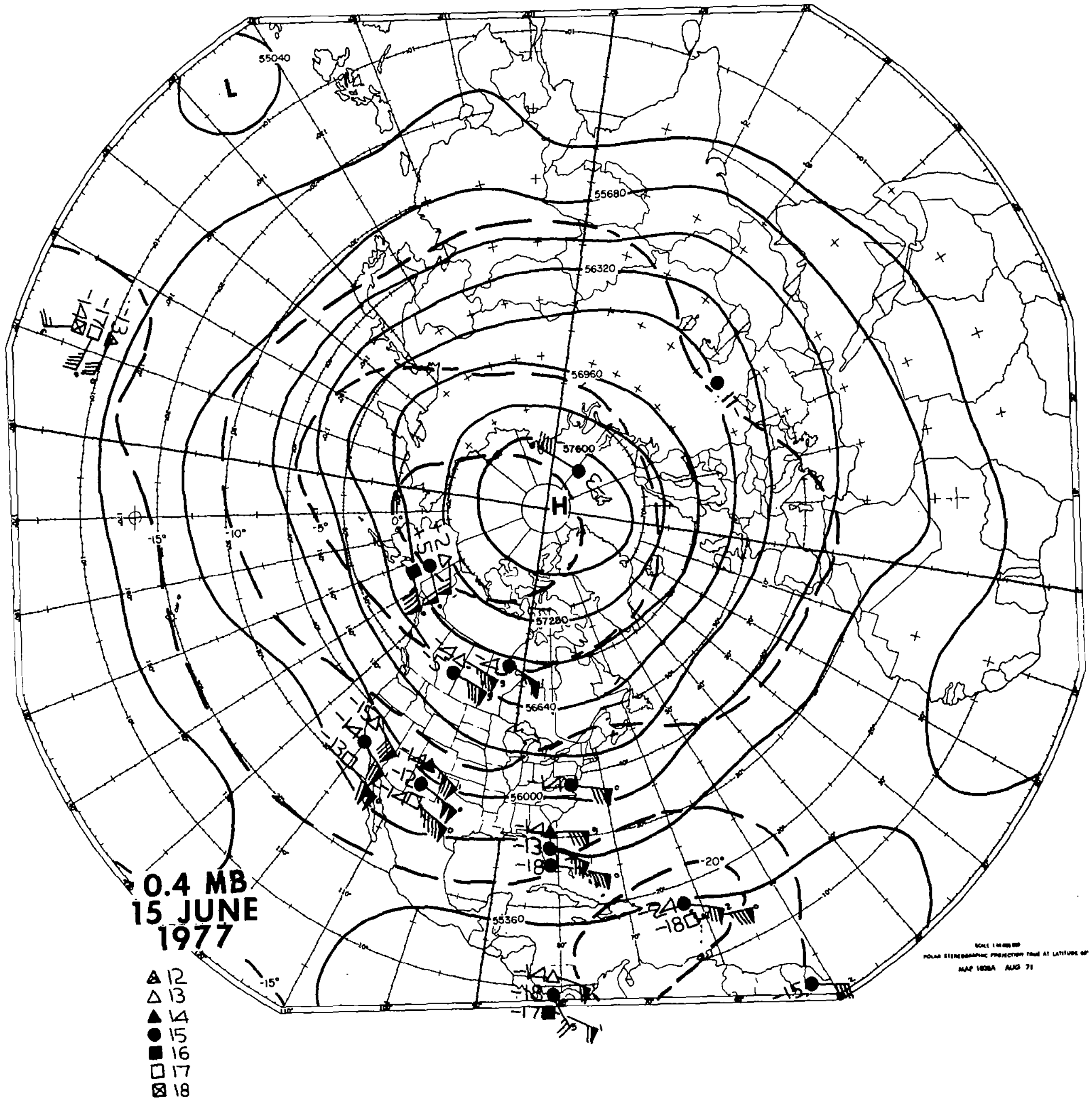
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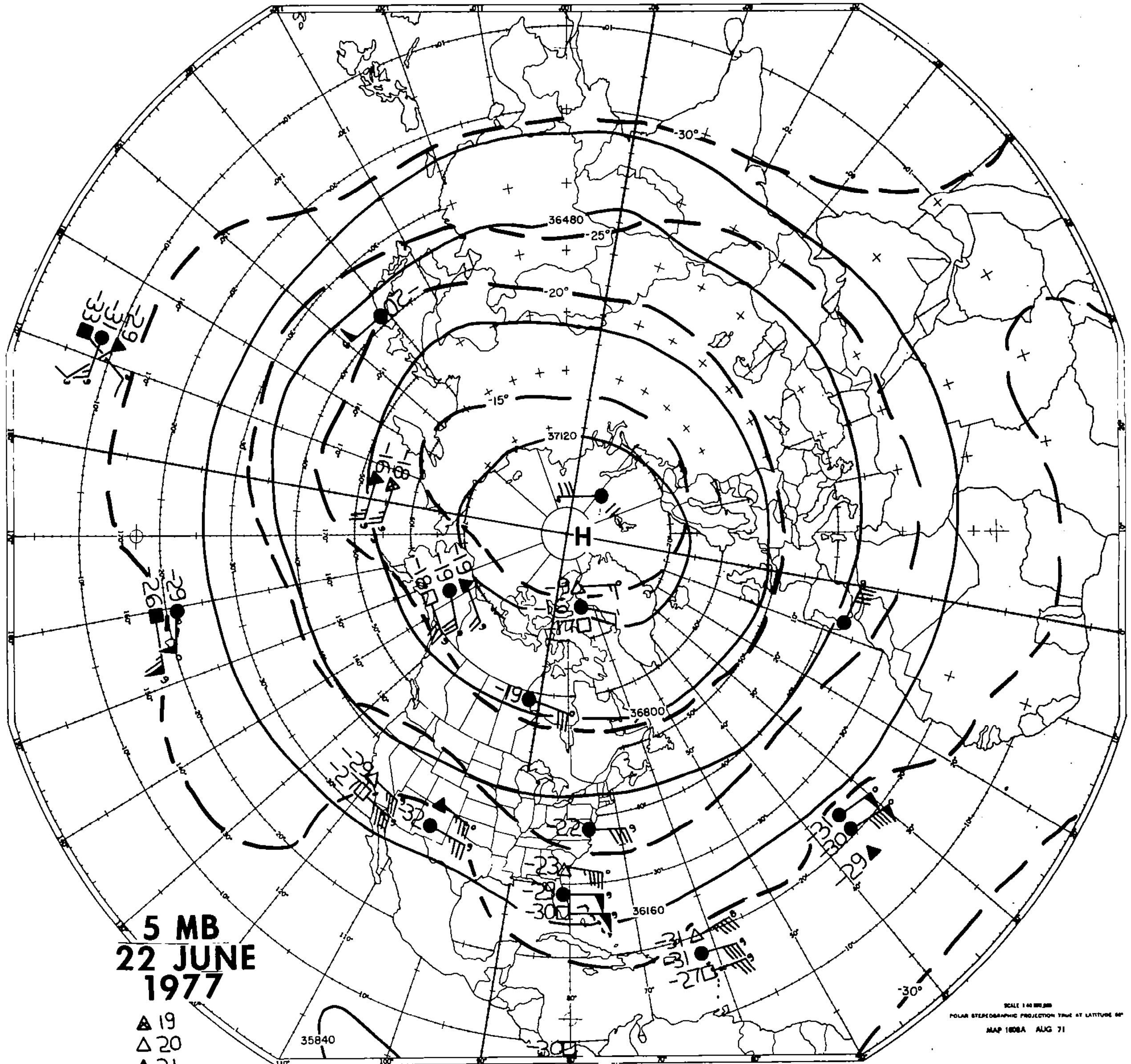

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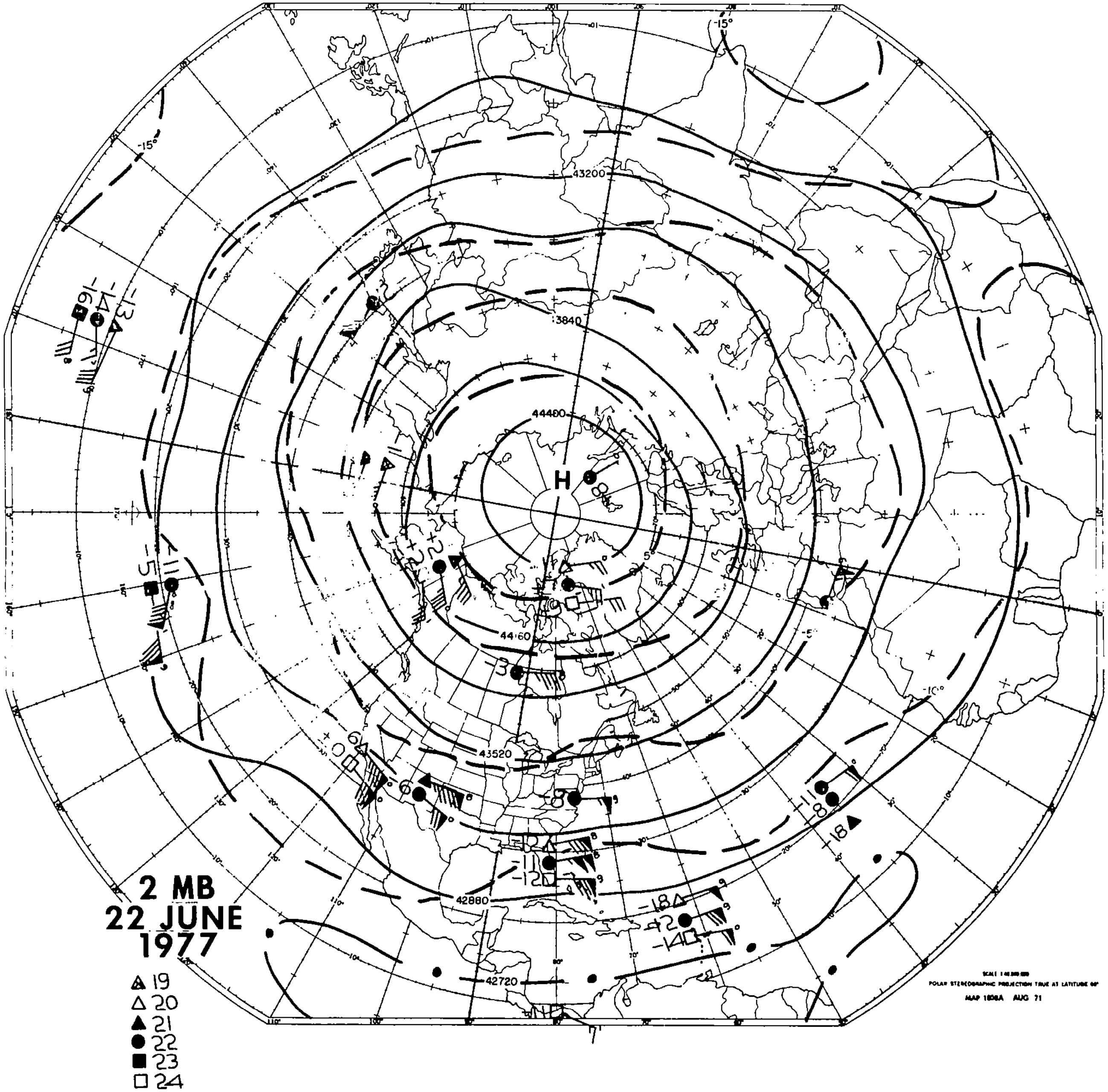
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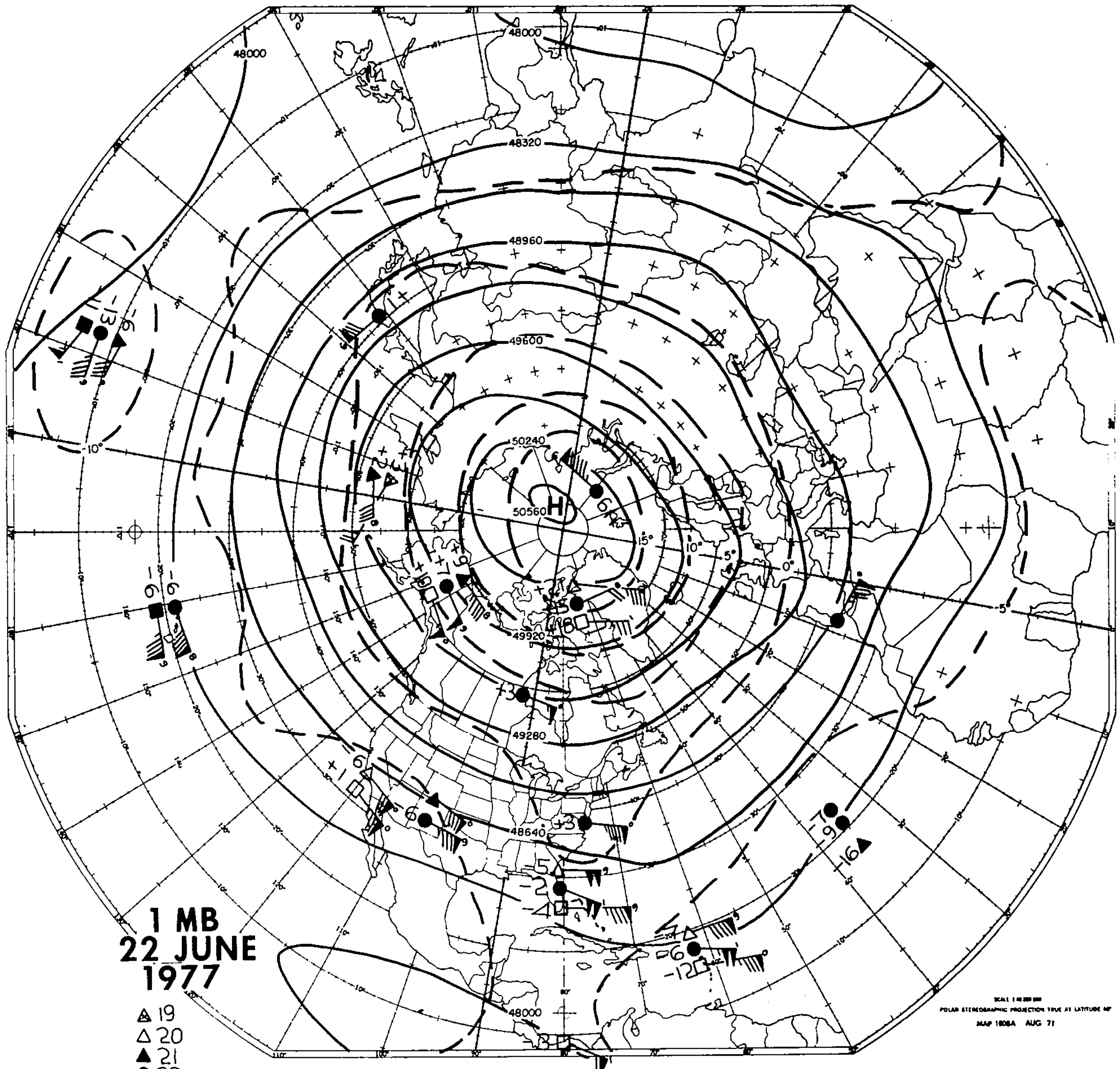

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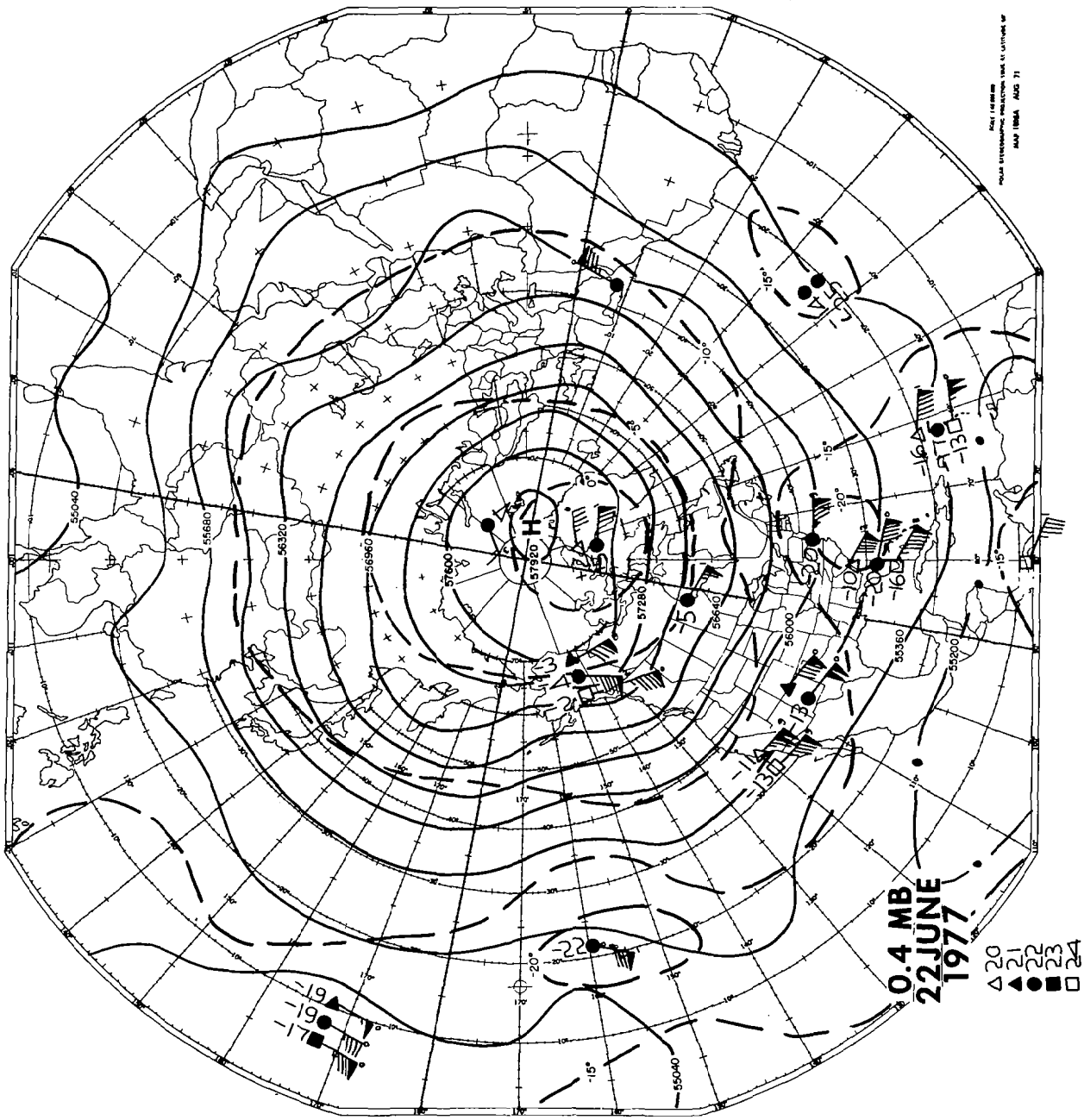
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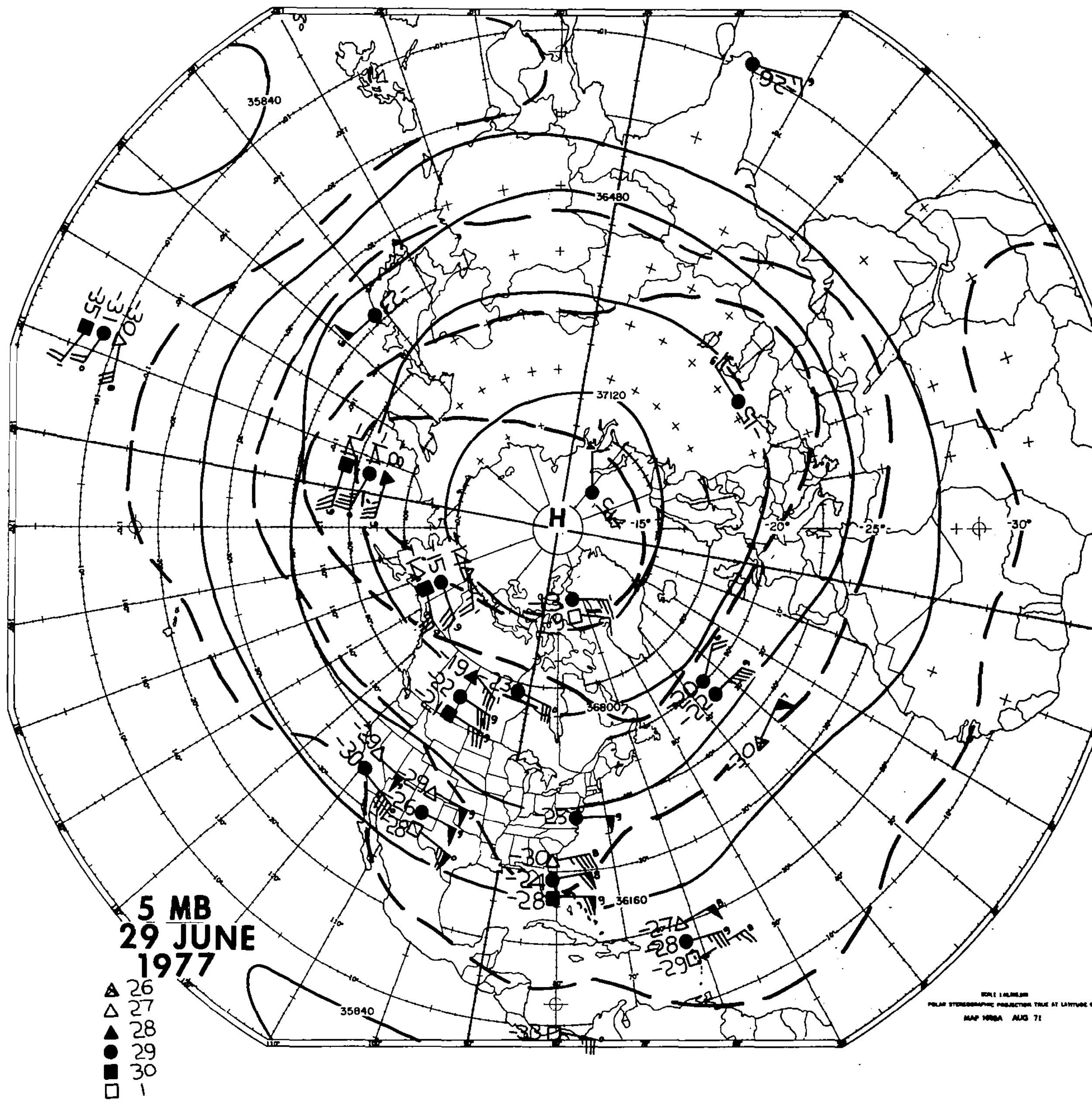

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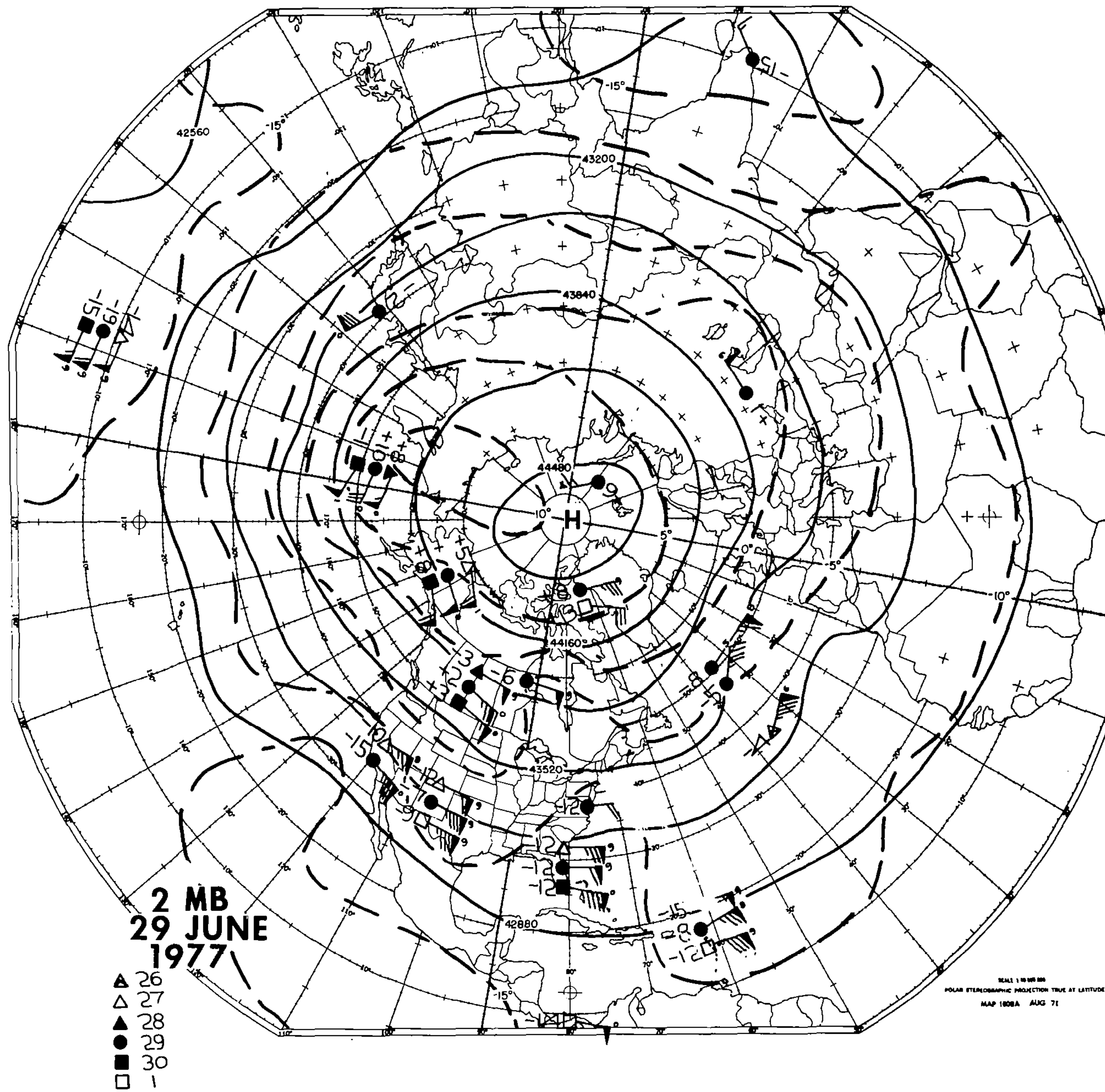
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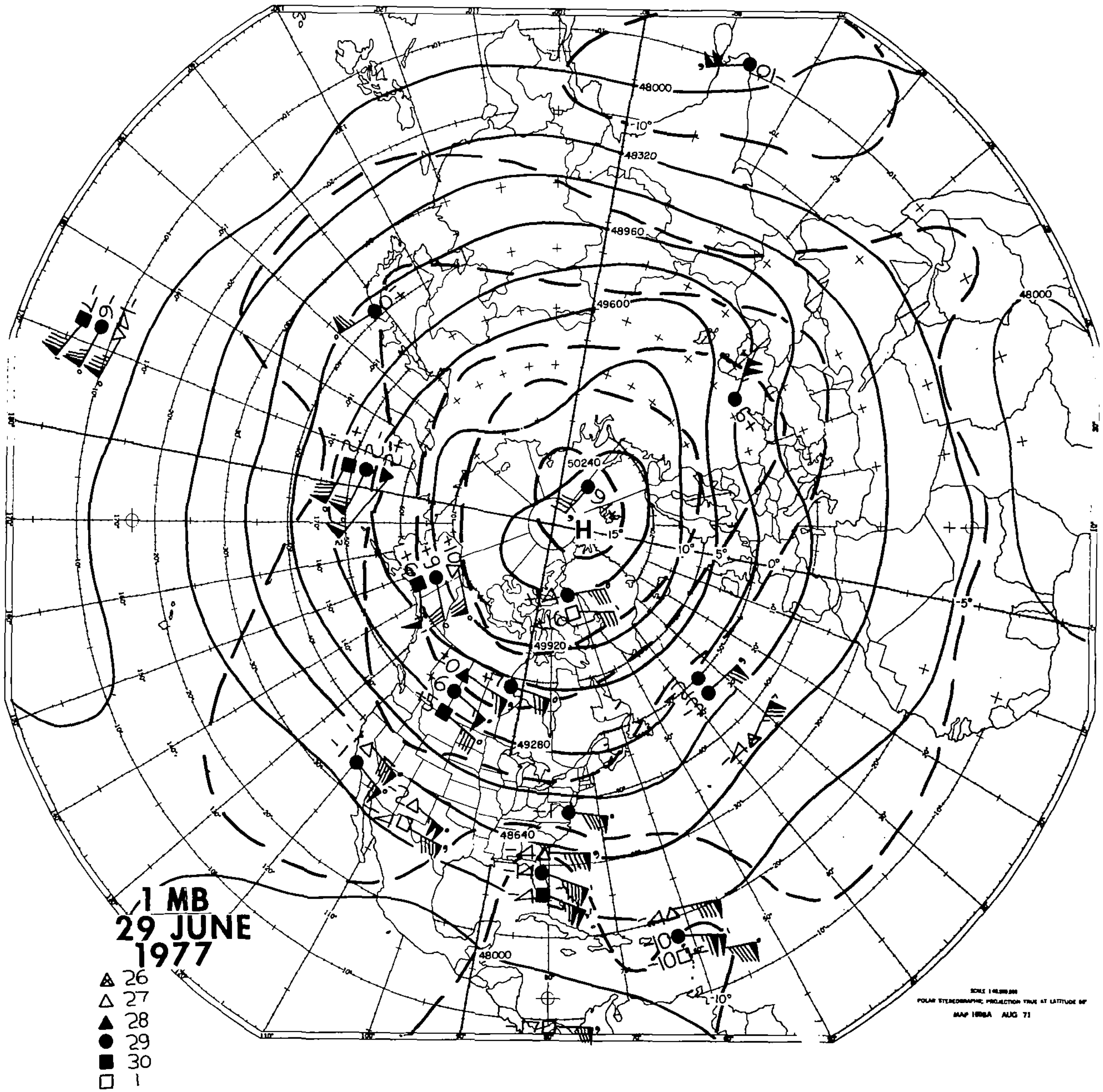
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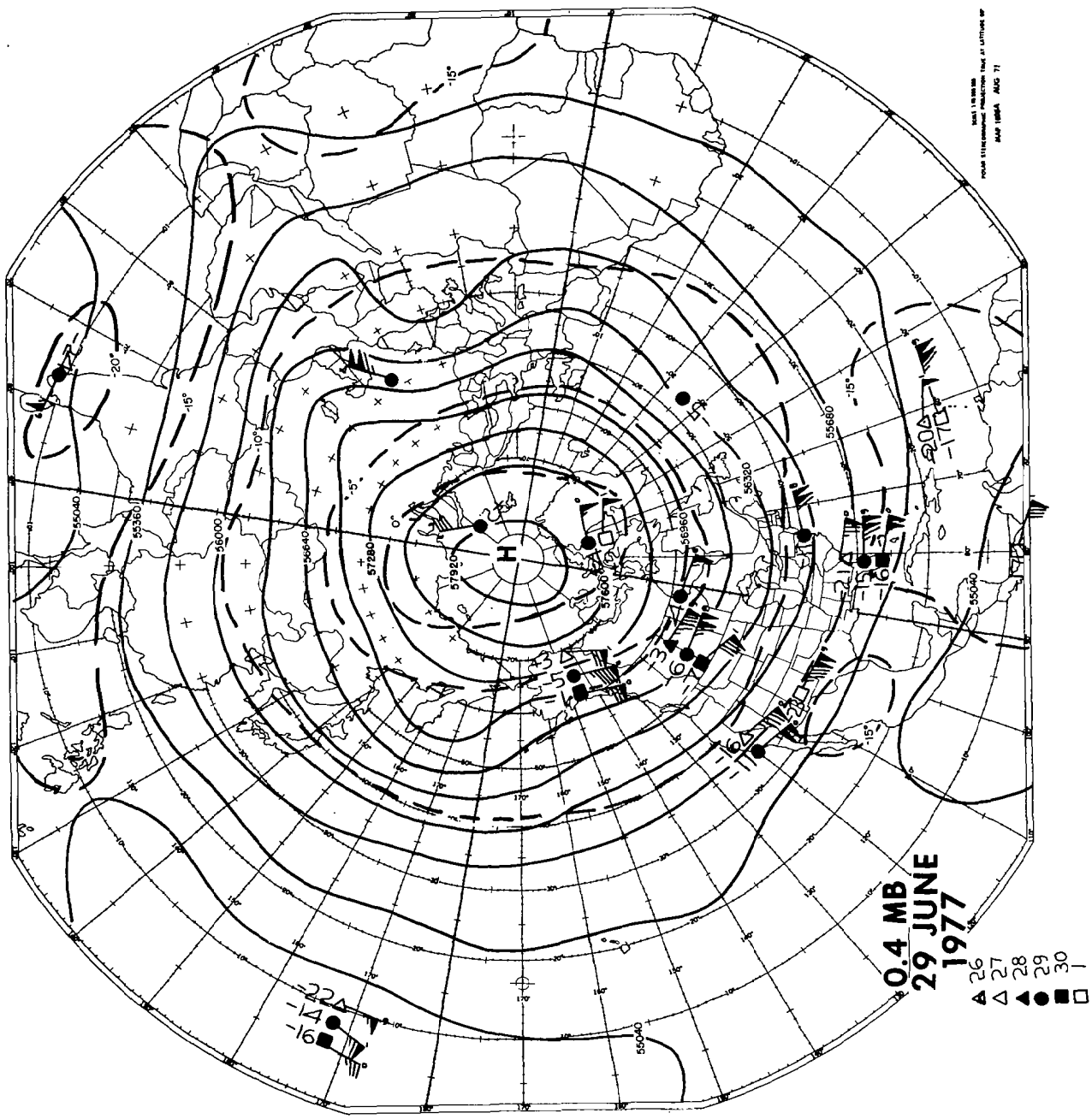

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NASA RP-1032		

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SYNOPTIC ANALYSES, 5-, 2-, 1-, and 0.4-MILLIBAR SURFACES FOR JULY 1976 THROUGH JUNE 1977	December 1978
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
STAFF, UPPER AIR BRANCH NATIONAL WEATHER SERVICE	

9. Performing Organization Name and Address	10. Work Unit No.
UPPER AIR BRANCH, NATIONAL METEOROLOGICAL CENTER NATIONAL WEATHER SERVICE, NOAA WORLD WEATHER BUILDING WASHINGTON, DC 20233	11. Contract or Grant No. P 55,946(G)

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16. Abstract

Meteorological rocketsonde and satellite radiance data are employed for analyses of a continuing series of high-altitude constant-pressure charts. The automated methods of data processing and the objective analysis procedures are described.

Broad-scale analyses of temperature and geopotential height for the Northern Hemisphere 5-, 2-, 1-, and 0.4-mb surfaces are presented for each week of the period July 1976 through June 1977. Brief discussions of the variations of the temperature and height fields throughout the period are also given.

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METEOROLOGICAL SATELLITES	GEOPOTENTIAL	
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